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Unmanned Tactical Autonomous Control and Collaboration measures of performance and measures of effectiveness

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THESIS

UNMANNED TACTICAL AUTONOMOUS CONTROL AND COLLABORATION MEASURES OF PERFORMANCE AND MEASURES OF EFFECTIVENESS

by

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September 2016

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13. ABSTRACT (maximum 200 words)

As the technological capabilities of the world's combat systems grow at a breathtaking pace, the reins by which humanity regulates and directs these instruments of destruction must keep pace. Unmanned Tactical Autonomous Collaboration and Control (UTACC) is a system of systems that will reduce the cognitive load of the warfighter while enhancing mission effectiveness. With any emerging concept, testing and development of UTACC are critical underpinnings of successful deployment to operating forces. This thesis sought to determine which measures of performance and measures of effectiveness (MOP/MOE) are most critical to the development of UTACC.

The MOP/MOE development process involved establishing a baseline layer of the Marine Corps Troop Leading Steps. The authors aligned the appropriate troop-leading step with phases in the context of a reconnaissance scenario. The next layer consisted of previously developed Coactive Design tasks and Individual Training Standards from the Marine Corps Task List associated with reconnaissance. The final product addresses both technical and tactical tasks required for efficient and effective mission accomplishment for any unit integrated with UTACC, but the effort is far from finished. Follow-on efforts should refine and expand the list to include different mission sets, tactical tasks and unit composition.

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UNMANNED TACTICAL AUTONOMOUS CONTROL AND COLLABORATION MEASURES OF PERFORMANCE AND MEASURES OF EFFECTIVENESS

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ABSTRACT

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LIST OF ACRONYMS AND ABBREVIATIONS

AAR	after action review
AC	air carrier
AOA	analysis of alternatives
BAMCIS	begin planning, arrange reconnaissance, make reconnaissance, complete the plan, issue the order, supervise
C2	command and control
C4I	command, control, communications, computers, and intelligence
CMU	Carnegie Mellon University
COA	course of action
COE	campaign of experimentation
COI	critical operating indicator
COMSEC	communications security
CONOPS	concept of operations
COP	combat operational picture
DAU	Defense Acquisition University
DIACAP	DOD information assurance certification and accreditation process
DOD	Department of Defense
DRAW-D	defend, reinforce, attack, withdraw, delay
EF21	Expeditionary Force 21
FSP	fire support plan
FR	facial recognition technology
GC	ground carrier
HUMINT	human intelligence
HVT	high-value target
IA	interdependence analysis
IERs	information exchange requirements
IR	infrared
ISR	intelligence surveillance and reconnaissance

ITL	in the loop
JCS	Joint Chiefs of Staff
KPP	key performance parameter
LIDAR	light detection and ranging
LTA	limited technical assessment
MAGCC	Marine Air Ground Combat Center
MCDP	Marine Corps doctrinal publications
MCOO	modified combined obstacle overlay
MCRP	Marine Corps reference publications
MCO	Marine Corps order
MCT	Marine Corps task
MCTL	Marine Corps task list
MCWL	Marine Corps Warfighting Laboratory
MET	mission essential task
MOE	measures of effectiveness
MOP	measures of performance
NAI	named area of interest
NMC	non-mission capable
NPS	Naval Postgraduate School
OODA	observe, orient, decide, act
OPD	observability, predictability, dependability
OPFOR	opposing force
OSMEAC	orientation, situation, mission, execution, administration and logistics, command and signal
OTL	on the loop
PIR	priority information requirement
PM	program manager
PMC	partially mission capable
POR	program of record
SALUTE	size, activity, location, unit, time, equipment

SOM	scheme of maneuver
SoS	system of systems
SOW	statement of work
TAW	task analysis worksheet
TTECG	Tactical Training Exercise Control Group
TTPs	tactics, techniques, and procedures
UAV	unmanned aerial vehicle
UAS	unmanned aerial system
UGV	unmanned ground vehicle
UGS	unmanned ground system
UIS	user interface system
UJTL	universal joint task list
USMC	United States Marine Corps
UTACC	unmanned tactical autonomous collaboration and control

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EXECUTIVE SUMMARY

The modern battlefield presents a complex and dynamic information environment unlike any that armies have faced in the history of warfare. Despite significant advances in technology, the modern warrior must navigate this rapid and confusing landscape while dealing with the ever-present rigors and dangers inherent in any violent clash of arms. Unsurprisingly, one of the greatest dangers that exists is information overload, which can paralyze an individual's decision-making process and render that person combat ineffective. The UTACC program intends to battle that cognitive overload. The purpose of this thesis is to create measures of performance (MOPs) and measures of effectiveness (MOEs) for UTACC, in an effort to support development of a system ideally bound for a program of record (POR), acquisition, and effective employment by the warfighter.

In order to create a table of metrics that will survive the test of time while still offering useful and actionable information to combat instructors, the search must begin with timeless doctrine and then integrate cutting edge concepts that include burgeoning capabilities, such as autonomous systems and laser technology. The authors merged Marine Corps Troop Leading Steps with Coactive Autonomy fundamentals, Interdependence Analysis tasks, and technical design metrics to create a comprehensive, multi-layered table, which they called UTACC Measures of Performance and Effectiveness (MOP/MOE) Table. This table would provide the baseline for technical assessments as well as tactical scenarios used for testing UTACC development.

The UTACC MOP/MOE Table contributed more than a dozen metrics to use during a limited technical assessment (LTA) of UTACC in April of 2016 at a testing facility in Quantico, Virginia. Upon completion of the LTA, the authors realized that while the UTACC MOP/MOE Table served a useful purpose for the later stages of UTACC development, additional technical metrics would be required for the early stages of development. Working closely with MCWL and the Center for Naval Analysis (CNA), they created a three-tiered system for evolving MOPs and MOEs along with the UTACC concept itself. This allowed the technical metrics to identify those areas that require further development inside the system itself while the higher level tactical MOPs and MOEs focused more on accomplishing the tactical mission within a combat scenario.

In the rush of excitement that surrounds any new technological concept, MOPs and MOEs often suffer from a lack of attention, as their development and implementation tends to focus more heavily on the restrictions and requirements of the new system instead of the heady optimism of possibility. Nonetheless, those same MOPs drive a concept systematically forward, creating new and enhanced capabilities with each iteration, and for this reason alone they demand full analytical rigor as UTACC develops into a Program of Record.

UTACC represents far more than a new system that offers our military brief superiority over its adversaries. Autonomy, artificial intelligence, robotics and computer technology, and the rapid proliferation of miniaturized drones all point toward an irresistible tide of change that is sweeping across the battlefields of the future. Powered by the concept of Collaborative Autonomy, UTACC represents the cutting edge of this revolution, bringing about the manifestation of a decades-old science fiction concept that envisioned warfare as existing primarily within the purview of machines. With this notion in mind, it is the authors' fervent hope that their work serve as a mere stepping stone to a flurry of future research, propelling the UTACC concept forward into an entire family of combat systems that will eventually take the place of America's sons and daughters on the field of battle.

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I. INTRODUCTION

Unmanned Tactical Autonomous Collaboration and Control (UTACC) is a complex robotic program still in its infancy. However, it is a concept that has the potential to change the relationship of man and machine on the battlefield forever. The concept employs a team of aerial and ground robots, in conjunction with complex software enabling their interaction and sensor information exchange, to work as semi-autonomous teammates with a small Marine Corps unit. In order to validate future research and funding to create a campaign of experimentation, there must be metrics to quantify success and failure for the system in various scenarios

The research began necessarily with a comprehensive investigation into the history of autonomy and robotics in war. Specific attention in this effort concentrated on the integration between machine and man. According to Chen and Barnes (2014), the key distinction between the levels of interaction between machine and man can be classified into two main areas: "on the loop" (OTL) and "in the loop" (ITL). One of the key benefits of OTL interaction is that it has the potential to free the human to concentrate elsewhere, thus decreasing the cognitive load on the warfighter; this is the primary goal of UTACC. The difficulty comes in creating quantifiable metrics for the relationship used to determine how effectiveness of mission accomplishment in a combat environment. To this end, achieving the vision of UTACC depends on the robust campaign of experimentation (COE).

The purpose of this thesis is to create those metrics of measures of performance (MOPs) and measures of effectiveness (MOEs), in an effort to support development of a system ideally bound for a program of record (POR) acquisition and effective employment by the warfighter.

A. VISION OF UTACC

As the UTACC program continues to develop, the Marine Corps Warfighting Laboratory (MCWL) will test the relationship between the different elements of UTACC as well as the integration between the UTACC and its human counterparts. These experiments will include mapping an area, identifying primary and alternate routes, correlating that information against known objectives and constraints, and then working in tandem to execute a mission of locating high-value targets (HVTs). The culminating event will likely occur in 2018 and will be a live force experiment at either the platoon or the company level. There will be a force-on-force component with one element playing the opposing force (OPFOR), one element conducting the mission in the traditional way, and one element conducting the mission incorporating UTACC into their mission execution. This will offer the opportunity to have a control group and a test group where we can compare the MOE of each group side by side, which will yield important insight into the added effectiveness of a unit equipped with UTACC.

Once completed, the experiments will generate data useful for determining UTACC viability. Assuming UTACC is useful, it may then progress into the USMC acquisition process, adopted as a program of record, and fielded to USMC forces. The concept of collaborative autonomy—working with robots as teammates—has far-reaching implications, not just for frontline troops but also at nearly every level of the military. It can allow us to leverage our capabilities far beyond the limits of a single human acting as the controller for a single robot (Jameson, Franke, Szczerba, & Stockdale, 2005, p. 2). With wireless communications and satellite technology to allow for continuous communications, a single human could one day control dozens or even hundreds of robot teammates, all operating semi-autonomously in consonance with each other and the scheme of maneuver. Every "dull, dangerous and dirty" (Singer, 2009) job that is currently being performed by a mortal human could be outsourced to a robot counterpart, reducing American loss of life during war. The list of potential impacts that UTACC and its predecessors could have on the military is truly endless, because it represents a paradigm shift in the way we conduct war, and thus the vision of UTACC could simultaneously be a vision of the future of warfare itself.

B. NECESSITY OF MOP/MOE

One common pitfall of innovations is that in the excitement of having a working product, designers and clients often forget to focus on how much impact the new technology actually has on mission accomplishment. A lack of MOPs and MOEs in place to track progress and document deficiencies breeds inaccurately evaluated programs. Additionally, these programs will not have the necessary framework for iterative improvements to the program and replication of the products. As mentioned in the J-7 Commander's Handbook for Assessment Planning and Execution, "The assessment process uses MOPs to evaluate task performance and MOEs to determine progress of operations toward achieving objectives, and ultimately the end state" (JCS J-7, 2011, p. ix). It was with this guidance in mind that the authors labored to create and refine the most relevant and significant MOPs and MOEs to support the COE. As UTACC takes its next steps toward inception, developers, evaluators, and decision makers will employ MOPs and MOEs as critical waypoints that will eventually lead to successful implementation for the entire family of systems that is sure to spring from this paradigm-shifting innovation.

C. THESIS IMPACT AND ORGANIZATION

The research team focused on three impact areas in support of the UTACC project. The first was a thorough review of the UTACC Thesis Concept of Operations (Rice, Chhabra, & Keim, 2015) and the embedded statement of work (SOW) to determine the scope of the program and better refine the expectations for execution. This analysis helped to narrow down the scope of tasks and sub-tasks needed for incorporation into the MOP/MOE framework. The second impact area involved reviewing relevant Marine Corps Orders (MCOs) to mesh doctrinal tasks and tactics, techniques and procedures (TTPs) with proposed autonomous capabilities to find any crossover tasks for evaluation during the collaborative execution of a mission. The third impact area concerned selecting and refining MOPs and MOEs to serve as control and evaluation measures for the entire COE that will follow. Although difficult, the information from this impact area formed the foundation of the entire research effort. The information also provided actionable information for future evaluation of UTACC systems.

This thesis consists of six chapters. The first chapter is an introduction to the thesis and the purpose behind the research efforts. It also includes the vision of UTACC and justification for the research, as well as a brief look at the future of autonomy in warfare. The second chapter, the Literature Review, explores the four main areas researched in preparation for the selection and refinement of UTACC MOPs and MOEs. Those areas include Autonomy, Marine/Machine Integration, United States Marine Corps (USMC) Missions, Doctrine and TTPs, and finally MOPs and MOEs as they pertain to military tasks and technology.

The third chapter, Research Methodology, details the MOPs and MOEs selection process. The process employed a thorough selection and refinement of salient topics, while eliminating irrelevant tasks to produce quantifiable metrics. When selecting metrics used in a future system, the analysis struck a balance between the limited technical assessment (LTA) technical measures of performance and MOPs and MOEs relevant to an operational UTACC unit. The section on Research Methodology will go into further detail about the rationale behind the choice of each metric type and its effective measurement at each stage of development. It further outlines the assumptions, constraints, definitions, comparisons and analysis that played a crucial role in the selection process.

The fourth chapter, UTACC MOPs and MOEs, is the heart of the thesis. This section lists the measures chosen by the authors and refined by the advisors, and will serve as the baseline for assessment of UTACC performance in each successive experiment in the years to come. The MOPs and MOEs place a heavy focus not just on the technical metrics requiring attention, but also on the metrics already being used to measure performance in operational units, which will help mitigate integration issues upon implementation into the fleet.

The fifth chapter, Feedback and Responses, covers the various feedback received after the experiment in early 2016 at Quantico, VA. This initial feedback allows the project manager to adjust the focus of effort and manage expectations as the next iteration of tests and experiments is conducted, ultimately taking one step closer to implementation.

The sixth and final chapter summarizes the results and recommendations for future research. As in the previous UTACC theses, the MOE/MOP thesis serves as another stepping-stone in the continued development UTACC and includes recommendations meant to aid the efforts of subsequent research teams.

D. SECTION CONCLUSION

UTACC amounts to much more than just fielding another robot on the battlefield; it is about revolutionizing warfighting. Whereas previous theses laid out the vision and concept of operations for the program, this thesis will provide the structure and metrics to allow development of a COE to take place. The COE in turn will advance the project steadily forward towards the ultimate goal of battlefield implementation.

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II. LITERATURE REVIEW

The four prior UTACC theses each produced independent literature reviews on the topics of collaborative autonomy, robotics, human/machine interaction, and USMC doctrine. Subsequently this thesis will briefly cover the relevant topics, calling upon previous works for reference, and then focus more heavily on MOP and MOE literature and its application for UTACC. The purpose of this literature review is to summarize publications and schools of thought regarding the inclusive and adjacent relevant topics to UTACC design. This includes the topics of Autonomy, Marine Machine Integration, USMC Doctrine, MOPs/MOEs, and other Defense Acquisition Metrics.

A. AUTONOMY

Although significant literature regarding automation and autonomy exists, it must directly relate to military applications to be truly useful in creating UTACC MOE/MOPs. This aspect helps focus the subsequent literature study and research. Prior UTACC research teams such as the CONOPS, Threats, and Analysis of Alternatives (AoA) all conducted thorough reviews of the history of automation, definitions and metrics for measuring levels of autonomy, and a brief overview of robotics and mobility autonomy (Rice et al., 2015). In their excellent thesis, Rice et al. addressed the concept of "collaborative autonomy," which is the ability of a human warfighter to work in tandem with autonomous and semi-autonomous robotic platforms to accomplish a mission. Accordingly, a defining characteristic of effective collaborative autonomy appears when the human can "command multiple vehicles with no more workload than a single vehicle" (Jameson et al., 2005, p. 2). This information provides an excellent base of knowledge for helping understand the field of robotics and autonomy on a conceptual level. However, it fails to provide sufficient detail on these concepts for our desired end state of a complete UTACC system.

For direct application to military operations, it is helpful to begin with a search of Department of Defense (DOD) literature. In this case, a task force report created in July of 2012 outlines current and future uses of autonomy within the DOD (DOD 2012).

While fully half of the report focuses on development and adoption challenges within operating forces, the other half focuses on autonomy's potential on the battlefield and the necessity of its implementation to maximum effect. Reduction of cognitive load and maximizing the strengths of machines are two key topics of the paper, as is illustrated in the quote:

> With proper design of bounded autonomous capabilities, unmanned systems can also reduce the high cognitive load currently placed on operators/supervisors. Moreover, increased autonomy can enable humans to delegate those tasks that are more effectively done by computer, including synchronizing activities between multiple unmanned systems, software agents and warfighters—thus freeing humans to focus on more complex decision making. (DOD, 2012, p. 1)

Another excellent resource for learning about the perceived challenges and opportunities of autonomy on the future battlefield is a workshop report from the Army Research Lab in Maryland. It states that:

> A critical challenge of the mid-21st century will involve successfully managing and integrating the collections, teams, and swarms of robots that would act independently or collaboratively as they undertook a variety of missions including the management and protection of communications and information networks and the provision of decision-quality information to humans. Success in this aspect of command and control would depend upon developing new C2 concepts and approaches, in particular, developing and fielding an effective hybrid cognitive architecture that leverages the strengths of artificial intelligence and human intelligence to go along with the development of new robotic, communications, information, and systems technologies. From the various observations of workshop participants, the traditional balance between offense and defense may shift as it becomes more difficult for the defense to keep up. (Kott et al., 2015, p. 23)

Many more references provide a fuller picture of the history and future of autonomy, especially as it relates to the DOD. Subsequent chapters use these references to help clarify and support the decisions made by the authors regarding selection of MOPs and MOEs, systems design analysis, campaign of experimentation, conclusions, and recommendations for further research.

B. MARINE MACHINE INTEGRATION

The interactive relationship between human operators and robotic systems falls into two categories: OTL, where the operator has supervisory control; and ITL, where the operator maintains active control of the system (Chen & Barnes, 2014, p. 1). The level of autonomy of UTACC drives system behavior dynamics. In the case of UTACC, the end state is the development of an OTL semi-autonomous system that limits the input required of the operator, in order to reduce the Marine's relative cognitive load. Using supervisory OTL systems that complete required Mission Essential Tasks (METs) could be a defining metric of success for UTACC.

Active ITL methodology requires a high degree of operator input, but without the appropriate system interface OTL methods are just as difficult themselves (Chen & Barnes, 2014, p. 1). Even in a supervisory role, the operator OTL must be able to accomplish the human elements of the given mission without the sensor interface overloading the operator. This also pertains to C2 decision makers who receive their own workstation interfaces with the related systems (Shattuck & Lewis Miller, 2006, p. 2). For example, decision makers who are located in tactical or operational-level operations centers must effectively supervise UTACC units, with regard to the information flow generated by a UTACC system of sensors and related operations.

UTACC operators are decision makers themselves, as integral parts of the collaborative system. As decision makers, they must have "perceptions, comprehensions, and projections" for decisions that accomplish the intended mission (Shattuck & Lewis Miller, 2006, p. 19). By "integrating a computational cognitive model" with a robotic platform, the two distinct tasks of thinking (reasoning) and basic mobility calculations for movement can be accomplished by the now more intelligent system (Trafton et al., 2006, p. 1). However, using a model of human information processing can be risky due to the abstract nature of describing human cognitive processes, which in turn complicates MOP/MOE development during system evaluation (Goodrich, 2004, p. 1).

In order to accomplish designated METs, the UTACC system will need to facilitate dynamic information exchange. Gold (2009) describes the nature of complex information exchange in the four areas of "robot to human, environment to robot, human to robot, robot to environment" (Gold 2009). In addition to these, UTACC planning would necessitate the inclusion of robot-to-robot information exchange, as the design incorporates more complex and multiple robotic systems. Sensors and computers organic to the robot systems will allow them to interact with the environment around them, but the UTACC collaborative concept will require these robots communicating this sensor data to the other UTACC elements involved in the mission including both human and machine teammate elements. It will therefore be necessary to ensure this communication piece is designed to present the sensor data to the decision maker in an effectively and timely manner. This subsequently facilitates his mental picture of the real environment around him and informs decision-making (Shattuck & Lewis Miller, 2006, p. 3).

C. USMC MISSIONS, DOCTRINE AND TTPS

Any UTACC system useful to a Marine unit must complement the mission in that it improves the means of mission accomplishment. In order to do this, the system must operate within USMC doctrine as dictated in the Marine Corps doctrine publications (MCDPs). Unfortunately, since this is an emerging technology no current USMC doctrine currently encompasses the use of autonomous systems.

As mentioned in the thesis by Rice et al., Expeditionary Force 21 (EF 21) is the document used to shape the vision for the USMC in the 21st century. EF21 principles call upon the USMC to be a modern force "that will preserve a quantitative edge" over its opponents by exploiting "innovative concepts and approaches" to problems (USMC 2014a). UTACC is the very definition of a program that exploits innovative concepts. If successful, it will offer a significant quantitative edge over our opponents.

Rice et al. claimed, "A mature UTACC system requires full integration of warfighting functions (intelligence, maneuver, fires, logistics, force protection, command and control)" (p. 17). In order to operate within USMC doctrine, this statement remains true. However, UTACC is not yet mature enough to address all of those warfighting functions. As such and per recommendation, the first task to tackle in the development of UTACC MOP/MOEs is addressing the Intelligence warfighting function. MOP/MOEs creation must begin with a thorough analysis of the intelligence tasks listed within the Marine Corps Task List (MCTL) 2.0, found in MCO 3500.26 (USMC, 2015b). Existing tasks relevant to UTACC reveal critical gaps in the current metrics, allowing the researchers to create additional UTACC-specific metrics to address those shortfalls. This, in turn, will allow for the creation of new doctrine inclusive of the autonomous systems and the collaborative methods by which they interact with their human counterparts.

D. MOPS AND MOES

Determining the efficacy of any system requires measurable effectiveness on both a functional and practical level. The MCTL provides metrics for accomplishing human tasks, assuming the parties involved in accomplishing those tasks are solely human. However, after analyzing these tasks and approaching them as function-based metrics, the potential exists to apply these tasks to robot- or collaborative-based systems. Approaching the tasks in this manner means functional task execution whether the platform for these functions is human or machine. Even though many existing Marine Corps Tasks have function-based metrics without a specific mention of humans performing the tasks, unidentified robot-centric metrics require consideration when employing UTACC. Because of this collaborative nature, re-centering the UTACC MOP/MOE development around fundamental doctrinal concepts is vital to determine and evaluate appropriate metrics for the emerging UTACC collaborative concept.

Regarding military operations and planning efforts, the Joint Chiefs of Staff J-7 break down the concept of Assessment into two measures: MOPs and MOEs (JCS J-7 2011, p. viii). MOPs link to the respective hierarchy of tasks in the MCTL (JCS J-7 2011, p. I-6). In relation to the application of MOPs for non-military tasks, such as research efforts, the development of the measures would occur at the agency or organizational level, falling on research institutions such as MCWL or Naval Postgraduate School (NPS). The concept of MOPs essentially boils down to the level of task completion, whether these tasks are from a service specific list or the universal joint task list (UJTL) (JCS J-7 2011 p. III-8).

The development of MOEs ties directly to and is even a precursor to the development of indicators, or metrics for both desired and undesired effects of operations (JCS J7 2011, p. III-10). MOEs provide a baseline model for measuring how organizational, system, or agency actions drive toward desired effects or drive results away from such effects. In military operations, the responsibility for creating these MOEs falls upon the respective joint planning group or operational planning team, and in some cases a dedicated assessment team may form (JCS J7 2011, p. III-9). Once the MOE model is in place, operators or sensors involved in the operations employ the model accordingly. In the case of military operations, this could mean data sensors or J-2 intelligence components that can recognize their respective indicators.

E. ACQUISITION METRICS

In formal DOD acquisitions program development, multiple metrics measure the progress of a system or technology. The current development maturity of UTACC as a potential DOD POR means that the MOPs and MOEs developed in this thesis may directly influence established acquisitions metrics as UTACC matures. Two of the more significantly program metric products, in accordance with the Defense Acquisitions University's (DAU) Program Manager (PM) Toolkit, are Key Performance Parameters (KPPs) and subsequent Critical Operating Indicators (COIs) used during testing and evaluation (Parker, 2011, p. 75).

Many types of KPPs are present within any given acquisition program, ranging from Net-Ready KPPs to Force Protection KPPs. The development of KPPs falls within the primary functional area of the PM. KPPs are innately complicated, even for a hardware acquisition program. When the program involves a system of systems (SoS) such as UTACC, the embedded interactions include both systems and subsystems. This creates an environment of metrics analysis that is easily muddled and exponentially more complicated. Therefore, any metrics or baseline evaluation criteria of a SoS, such as pre-refined MOPs and MOEs prior to Milestone A, can facilitate a more efficient and effective KPP development process by the PM.

The follow-on metrics taken from a program's KPPs eventually become the COIs. COIs apply to the various development and testing stages of a program prior to and concurrent with a low rate initial production (LRIP) stage. COIs are critical to evaluating the performance of a system as its development is finalized, and the latest designs begin coming off of the LRIP line to be issued to the end users. COIs will therefore be one of the final manifestations of initial MOPs and MOEs prior to a system becoming operational. If the initial MOPs and MOEs set the PM and his program up for success, COIs will accurately ensure the systems functionality in various critical aspects for the final end user. The PM's Toolkit implicitly tells us that successful MOPs and MOEs will contribute to and enable development of the best possible product for the DOD warfighter.

F. SECTION CONCLUSION

This literature review served to summarize information that is readily available about the history and current uses of autonomous and robotic technology, even as it pertains to warfare applications. It also covered how MOPs and MOEs employment in the past quantified the capabilities of new and existing units and technological platforms. The rest of the thesis will build upon the knowledge to determine the most effective metrics by which to measure the capabilities of a brand new type of autonomous system; one that for the first time in human history will serve in true collaborative fashion with Marines. These metrics will measure not only how well the robot and human perform individually, but how well they work *as a team*.

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III. RESEARCH METHODOLOGY

A. BASIC SYSTEMS ENGINEERING PROCESS

The primary process for developing MOP/MOEs in accordance with guidance from program sponsors begins with using standard systems engineering processes based on the UTACC CONOPS thesis. Rice et al. conducted a thorough analysis of the basic systems engineering processes using definitions and overarching guidance out of the Systems Engineering Management textbook (Blanchard, 2008). Based on these recommendations, the authors treated UTACC as a SoS capable of independent operations, but operating within the C2 model of the Marine Corps to ensure unity of effort during operations (Rice et al., 2015). According to their findings, "The steps that were most applicable to this thesis were: definition of problem, operational requirements, and functional analysis. The entire process also incorporated feedback mechanisms as an important element of concept generation" (Rice et al., 2015, p. 21).

The problem has already been defined earlier in this paper, but the operational requirements identified by the CONOPS thesis yielded great insight into what needed to be developed for MOPs and MOEs, specifically the Performance and Related Operational Parameters, Utilization Requirements, and Effectiveness Requirements. Finally, the Functional Analysis served as the "heart of the concept generation" for the UTACC CONOPS thesis (Rice et al., 2015, p. 23) which will, in turn, allows for the development of relevant MOPs and MOEs. The following chapters explain this in detail.

B. UTACC DEFINITIONS

During Team 1's development of the UTACC Concept of Operations, the following used terms enable consistency when discussing the concept with the many UTACC stakeholders. By nature of the UTACC family of theses, these definitions come directly from the Rice et al CONOPS thesis for consistency in the progression of the UTACC program.

Small tactical unit–a Marine Corps infantry fire team, infantry squad, or reconnaissance team.

UTACC–armed Marine(s) conducting operations with the assistance of a mix of semi-autonomous unmanned ground and air vehicles. One UTACC system is a triad of a human component, an air component, and a ground component. (SOW)

Human Component– envisioned as a small tactical unit leader. UTACC should also be able to work with, provide input to, and receive direction from all members of a small tactical unit.

User Interface System (UIS)–a combination of devices that stimulate multiple senses in the human. For example, this might allow him to do the following: see a map of the operations area or a live video of a specific person of interest; hear a warning informing him that a component has experienced a critical system failure; or, feel a warning of nearby enemy force. In addition to providing input to the human, the UIS will also receive input from the human and then relay that input to all the other UTACC components. The human inputs can also come in a variety of ways: hand and arm signals directing the tactical movement of UTACC; verbal messages given to human teammates as well as UTACC components; touch gestures/drawings on a UTACC generated map or preformatted report.

Air Carrier (AC)–an unmanned ground vehicle capable of carrying, launching, recovering, and refueling multiple unmanned air vehicles (UAVs). In addition, the AC will be capable of carrying additional supplies (e.g., ammunition, food) for the small tactical unit as well as acting as a communications relay for the UTACC components. In the future, this vehicle will be capable of high-speed travel over rough terrain and off-road areas.

Unmanned Air Vehicle (UAV)–an aerial platform capable of carrying any number of sensors to support mission specific intelligence, surveillance, and reconnaissance (ISR) requirements and capable of vertical takeoff and landing. The UAV will be capable of serving as a vital communications relay node between geographically separated ground components.

Ground Carrier (GC)–an unmanned ground vehicle capable of carrying, deploying, and recovering multiple unmanned ground vehicles (UGVs). In addition, the GC will be capable of carrying additional supplies (e.g., ammunition, food) for the small tactical unit as well as acting as a communications relay for the UTACC components. This vehicle will be capable of high-speed travel over rough terrain and off-road areas.

Unmanned Ground Vehicle (UGV)–mission specific unmanned systems capable of performing discrete ISR missions. The UGVs, similar to the

UAVs, could have a variety of sensors to support mission specific ISR requirements.

Cue–is a notification issued by the UIS to the Human Component where human intervention is not required.

Alert–is a prompt issued by the UIS to the Human Component requiring human intervention. (Rice et al., 2015, pp. 26–27)

These terms remain relevant in the discussion of MOP/MOEs since they relate to the various components of the UTACC system.

C. UTACC ASSUMPTIONS

The overall concept of operations (ConOps) for UTACC included numerous assumptions that were necessary to frame a starting point for this emerging program. The ConOps thesis assumed UTACC as a *technology agnostic* concept (Rice et al., 2015, p. 27). Subsequent analysis of alternatives (AoA) helped narrow down the technology and systems likely qualified for current UTACC demonstrations. However, it remains important to develop the UTACC program with as little pigeonholing as possible, to allow for incorporation of new and emerging technologies to the system that might ultimately become a POR. For developing MOEs and MOPs, the UTACC concept was as technologically agnostic as possible, but also had to recognize the functional systems and technologies actually used in the April 2016 LTA. For example, one sensor system used in the LTA was a specific technological capability in the form of Light Detection and Ranging (LIDAR). Realizing that this technology could be improved or refined in the future prior to UTACC deployment, researchers assumed that MOPs and MOEs related to UTACC detection tasks in the LTA would be applicable to future demonstrations.

One other specific assumption made was that UTACC could apply current USMC Task List elements in such a way that robots performing a task would have the same effective result as a human performing a task. This was a necessary assumption to facilitate using the MCTL as a starting point for employing MOPs at the UTACC April 2016 LTA. Robot functionality is intrinsically different from human functionality in the form of Marines operating given tasks. However, the result of those actions (to accomplish the tasks) is assumed commensurate with human actions currently undertaken by Marines to accomplish listed tasks from the MCTL.

The last assumption was that the task list metrics used for the April 2016 LTA would accurately reflect metrics applied to UTACC in future LTAs and ultimate operational deployment. If LTA activities could be applied to the planned MOPs and MOEs, then they would also serve as reasonable metrics for future employment of UTACC. This was a relatively bold assumption due to the dynamic nature of plans and fruition of subsequent UTACC LTAs and demonstration events put on by MCWL. Fluctuating factors such as manpower and budget restrictions, as well as changing MCWL program priorities, could easily change the nature and activities of future UTACC events. With this in mind, the MOPs and MOEs required a “first look” in action at a baseline LTA. That baseline would subsequent serve to gauge the MOP and MOE usefulness for future UTACC LTAs and other events. After multiple applications to an assessment or demonstration event, the MOPs and MOEs could be accepted, revised, or thrown away.

D. UTACC CONSTRAINTS

One of the primary constraints of developing the MOPs and MOEs was the limited and dynamic nature of the April 2016 LTA. Both the scope and constitution of the test events endured multiple amendments prior to the actual events taking place. These amendments occurred concurrently with the drafting of the initial MOPs and MOEs.

During the dynamic planning process for the LTA, it became apparent that the actual tasks given to the UTACC system would be limited. This meant that the proposed MOPs and MOEs would be constrained by the number of scenarios in which they could be evaluated (both the UTACC system itself and the metrics). The limited nature of the LTA provided a brief opportunity to evaluate metrics in different scenarios and became a significant factor in the aforementioned assumptions made about the applicability of the MCTL-based MOPs and MOEs to UTACC as a whole.

This and other constraints meant that additional risk existed for the complete evaluation of the proposed MCTL-based MOPs and MOEs. It is evident that the amendment of test event plans will restrict the number of scenarios tested in future cases as well.

E. ROLE OF DOCTRINE AND TTPS

Marine Corps doctrine lays the foundation for how Marines operate in both training and combat environments. Eleven Marine Corps doctrinal publications (MCDP) cover warfighting fundamentals and beliefs (Global Security, 2016). These publications contain innumerable lessons gleaned from the battlefields of history, spanning the breadth of time from the ancient teachings of Sun Tzu to the more modern and exhaustively studied works of the Prussian military theorist Carl von Clausewitz. Marine leaders study these publications at their basic training schools, committing many of the lessons and concepts to memory for use throughout their careers. In addition to the MCDPs, nearly 100 Marine Corps Warfighting Publications (MCWP) "have a narrower focus that details TTP used in the prosecution of war or other assigned tasks" (Global Security, 2016). Essentially, MCWPs take the concepts outlined in the MCDPs and break them down into actionable tactics, techniques and procedures (TTPs) to use in planning and executing combat operations.

The final element of Marine Corps doctrine that allows for quantifiable measurement of progress and proficiency in military skills and capabilities is the MCTL. This is a comprehensive list of all of the relevant tasks that a Marine unit can and should conduct in order to train and equip its personnel, deploy to training and combat missions, execute training and combat operations, sustain the force, fulfill its garrison responsibilities, and successfully navigate myriad other potential contingencies. An organization called the Marine Corps Task List Branch (MID/MCTL) within the Capabilities Development Directorate, Deputy Commandant, Combat Development and Integration (DC, CD&I) in Quantico, Virginia manages the MCTL. According to their mandate, "The mission of the Marine Corps Task List (MCTL) Branch is the program management and maintenance of MCTL and its life cycle of products" (Marines, 2016). They go on to describe the MCTL and its uses in detail. Below is an excerpt from the MCTL Branch website:

> MCTL is the authoritative, standardized, and doctrinally-based lexicon of USMC capabilities defined as Marine Corps Tasks (MCTs) and used by units, installations and the supporting establishments in the development of Mission Essential Tasks and Task Lists (METs/METLs). METs/METLs are the list of "essential," critical, discrete, eternally-focused MCTs that directly enables the execution of the organizational mission. Capabilities, defined as "MCTs" and resident in MCTL enable Commanders to document their command warfighting operational abilities as METs/METLs, providing force sourcing planners, trainers and concept developers with single common language "tasks" articulating both Joint and USMC-specific, manpower, equipment and training requirements. (Marines, 2016)

Out of these task lists emerge the essential elements used in establishing metrics that allow us to measure a unit's proficiency and readiness for combat operations: MCTs. Embedded within each MCT is collection of the most relevant MOPs and MOEs for that task, which allows for quantifiable feedback as to the level of mission success or failure. Table 1, which was taken from the MCTL section of the official website of the United States Marine Corps (Marines, 2016), is an overview of how a MCT is defined, broken down into its basic parts, and how each part is assigned a series of metrics that can be measured in percentages, days, hours, and so on. This table could convert to a checklist and placed into the hands of a Marine evaluator who will observe, record, and report the data as accurately as possible.

Table 1. Excerpt from MCTL-2.0 July 2016. Source: Marines (2016).

MCT 2 DEVELOP INTELLIGENCE

To develop that intelligence which is required for planning and conducting tactical operations. Analyzing the enemy's capabilities, intentions, vulnerabilities, and the environment (to include weather and the application of tactical decision aids and weather effects matrices on friendly and enemy systems, and terrain) derives it. This task includes the development of counterintelligence information. **(JP 2-0, 2-01, 2-01.3, 2-03, 3-07.1, 3.07-4, 3-09, 3-10, , MCDP 2, MCRP 2-3A, MCWP 2 Series, 3-35, 3-2, NDP 2, NWP 2-01, NTA 2)**

M1	Percent	Of targets accurately identified.
M2	Percent	Of targets accurately located.
M3	Days	In advance of collection intelligence requirements identified.
M4	Hours	Turnaround time to process new intelligence data.
M5	Hours	Warning time for significant enemy actions.
M6	Percent	Of collections requirements derived from PIRs.
M7	Hours	Since most current intelligence information collected.
M8	Percent	Of PIRs answered in time to meet current operational needs.
M9	Y/N	Conduct Intelligence Operations with organic personnel and equipment.

The MCTs covered in the Intelligence MCTL cover every major area of intelligence operations, with thousands of associated MOP/MOEs. The problem with the existing MCTs is that they do not account for a system of robot teammates that have an entirely different suite of both needs and capabilities. Chapters IV and V discuss this program further.

F. MISSION AND INTERDEPENDENCE ANALYSIS

Before this thesis, excellent research by Captain Matt Zach, *Unmanned Tactical Autonomous Control and Collaboration (UTACC) Coactive Design* (2016) effectively laid the groundwork for the development of UTACC MOPs and MOEs. Captain Zach describes Coactive Design by paraphrasing partially from researcher Dr. Matt Johnson of the Florida Institute for Human & Machine Cognition:

> (A) method for designing interdependent systems that uses a design tool called an interdependence analysis table, which details human-machine requirements. The requirements guide implementation of the system, providing teamwork infrastructure. The accumulation of all the capabilities under the teamwork infrastructure determines the runtime options, which determine performance. (Zach, 2016, p. 4)

In creating the MOPs and MOEs for UTACC, the authors realized early on that their efforts nest within the Coactive Design framework. More specifically, the tasks embedded within the IA tables that would govern UTACC design and implementation.

The Zach thesis explains the construction of UTACC IA tables. He describes how he aligned the embedded tasks and subtasks with the mission planning and execution model created by Rice et al. (2015), while making the necessary modifications required applying Coactive Design techniques to the model. The Marine Corps Troop Leading Steps provide a framework for organizing the flow of tasks and selecting the critical primary and sub-tasks.

The Marine Corps Troop Leading Steps consist of six primary actions described by the acronym BAMCIS, which stands for Begin planning, Arrange for the reconnaissance, Make the reconnaissance, Complete the plan, Issue the order and Supervise (USMC, 1998a). Zach used BAMCIS as the backdrop and then overlaid his IA tables on each of the phases, with incorporation of the Rice et al. task analysis worksheets. Zach pulled out the primary tasks relevant to UTACC Coactive Design and broke them into subtasks to pair them with their respective observability, predictability, and directability (OPD) requirement elements (Zach, 2016, p. 2-3). As he continued through each phase, more and more detail emerges as to the design requirements necessary for UTACC to complement a Marine Corps tactical unit through a real mission. This presents astonishingly complex and fluid situations that require continual updates to the decision template algorithms running in the background of UTACC software.

Table 2 is an example of an IA table that outlines only one task within the “Make the Plan” portion of BAMCIS. Notice how the requirements multiply when the subtasks are taken into account, capacities for each subtask require more design consideration, multiple options present themselves in the form of the optimal Unmanned Aerial System (UAS), Unmanned Ground System (UGS) and human Marine mix, and finally, each subtask has an associated set of OPD requirements in order to create an effective system. Within Table 2, color-coding is provided to exemplify what subtasks were performed at (yellow) or above (green) acceptable threshold, or perhaps did not apply in that particular scenario (grey).

Table 2. Make Reconnaissance: Return, Scan, Alert, Notify, and Monitor. Source: Zach (2016).

			Option 1			Option 2			Option 3			
Tasks	Subtasks	Capacities	UAS	UGS	M	UGS	UAS	M	M	UAS	UGS	OPD requirements
Conduct Detailed Mapping	Return to Selected Emphasis Area(s)	Prioritize List of Areas Needing Refinement										Prioritize list of areas needing refinement
		Resolve Airspace										Humans can deconflict air space and it would also be helpful to build in this capability into the UAS.
	Scan Selected Emphasis Area(s)	Execute Detailed Mapping Protocol										UxS based on input above self determines mapping protocol. Assumed that Marines could map the area but the time is assumed to take too long.
		Build Detailed Map Collaboratively										Built between UxS's. assume CMU collaborative mapping capability extends to all UTACC UxS's.
	Alert Team to Relevant Map Info	Transmit Map Information										Systems can use each other to find most efficient way of transmitting data.
	Notify When Near Completion of Mapping	Alert Marine When Planning Threshold Hit										Marines in the initial planning will have to create initial threshold and communicate it to the UxS's and UxS's will need to talk back to Marines when threshold hit.
	Monitor System Health	Understand When to Return for Maintenance/ Refueling										UxS's need to monitor state with relation to task and health RTB when required. Marines have the option to monitor their state and then direct UxS's to RTB. Assume UAV sends mapping data in real time back to UTACC manager. Assume health monitoring display.

The analysis continues through each portion of BAMCIS, culminating in a comprehensive list of tables that provide critical information for developing both technical and tactical MOPs and MOEs for UTACC (Zach, 2016). The next section describes how the authors created a comprehensive list of MOPs and MOEs by leveraging the layers of BAMCIS, Demonstration Phases, Coactive Design IA tables, and MCTL 2.0. These MOPs and MOEs not only address the tactical considerations for Marines operating within USMC Warfighting Doctrine, but also the software and operating system requirements of semi-autonomous machines working together with human teammates to fulfill Intelligence gathering requirements.

G. ANALYSIS DEVELOPMENT LAYERS

To properly analyze and measure both tactical proficiency and technical reliability in a complex network-centric, semi-autonomous system like UTACC, the analysis must penetrate multiple layers of functionality as well as cover the breadth of tactical tasks it likely called upon to accomplish. As previously mentioned, in order to develop MOPs and MOEs that adequately address these areas, the authors chose to nest their efforts within frameworks developed by Rice et al. (2015) and Zach (2016). This effort called for the use of the Marine Corps Troop Leading Steps (BAMCIS) and Coactive Design to develop IA tables full of UTACC-specific tasks and subtasks. However, this information only covers part of the analysis required to develop a full suite of MOPs and MOEs. One must also take into account the intelligence gathering tasks from the MCTL 2.0, and those tasks must align with a realistic scenario capable of being modeling and testing in a relevant environment.

To this end, the authors decided to focus on the UTACC Limited Technical Assessment Part 2 (LTA-2), an event meant to serve as both a technical assessment for the design team and a demonstration to MCWL representatives of current UTACC progress and future capabilities. LTA-2 provided an excellent venue for developing and testing various aspects of the MOP and MOE framework, and the phases of LTA-2 mirrored an important type of intelligence gathering operation, which prompted the authors to overlay the LTA-2 phases onto BAMCIS to create the first two layers of analysis.

Thus, BAMCIS provided the backdrop for analyzing UTACC operations and the MCWL LTA-2 phases provided guidance on the most relevant tasks and subtasks required at any given time. Subsequently, the last layer of analysis to conduct consisted of the MOPs and MOEs themselves and how they apply to the given LTA phases. The authors assimilated this layer by combining the MCTL 2.0 and UTACC IA tables and painstakingly drawing out the most relevant tasks and subtasks for both human and machine to create a comprehensive list of metrics by which to measure UTACC in each phase of the scenario. Once this was complete, the authors identified gaps in the model related to UTACC-specific metrics that required creation.

1. BAMCIS

The Marine Corps prides itself on pushing authority down to the lowest level and allowing junior Marines to lead their units under the guidance of the overarching commander's intent. As such, every Marine repeatedly memorizes and practices the basic troop leading steps. This breeds proficiency in planning and executing missions, which allows commanders to issue their intent without micromanaging their troops. Figures 1–3 show the essential elements of BAMCIS, which appear in detail in the respective Marine Corps publication.

TROOP-LEADING STEPS

1. Begin Planning.

a. Plan the use of available time.

b. Estimate the situation based on mission, enemy, terrain and weather, troops and support available-time available (METT-T).

(1) Mission. The mission must identify—

- Task assigned.
- Who, what, where, and when.
- Commander's intent (why).

(2) Enemy. Commanders—

- Estimate the enemy's composition and disposition based on size, activity, location, unit, time, and equipment (SALUTE), and strength.
- Estimate the enemy's capabilities and limitations to defend, reinforce, attack, withdraw, and delay (DRAW-D).
- Estimate the enemy's most probable course of action.
- Identify vulnerabilities that can be exploited.

MCRP 3-11.1A **Commander's Tactical Handbook**
Troop Leading Steps **1** **Troop Leading Steps**

Figure 1. BAMCIS Outline from the MCRP 3–11.1A. Source: USMC (1998a).

The early stages of BAMCIS require significant amounts of research and intelligence gathering traditionally left up to the leaders and their staff. For simplicity, Marines refer to this as a Mission, Enemy, Terrain and Weather, Troops and Fire Support Available-Time Available (METT-T) analysis, and includes every relevant piece of gathered information so that the commander can make the most informed and tactically correct decisions possible. Identifying key terrain and features will offer tactical advantage to friendly forces requires specific emphasis, which is evident in the UTACC scenario.

Troop Leading Steps 2 Troop Leading Steps
MCRP 3-11.1A Commander's Tactical Handbook

(3) Terrain and weather are evaluated based on key terrain, observation and fields of fire, cover and concealment, obstacles, avenues of approach, and weather/astrological data (KOCOA-W).

(4) Troops and support available are evaluated based on the following:

- People.
- Human factors.
- Equipment.
- Logistics.
- Fire support.
- Space.

(5) Available time. Commanders use the following to plan available time:

- 1/3 - 2/3 rule (allocate 2/3 of available time for subordinates).
- Backward planning.
- Parallel and concurrent planning.

c. Issue warning order.

2. Arrange.

a. Movement of unit (where, when, and how).

b. Reconnaissance.

Figure 2. BAMCIS Outline from the MCRP 3–11.1A (continued from Figure 1). Source: USMC (1998a).

Arranging for movement and reconnaissance and the actual conduct of the reconnaissance are the subjects of the initial UTACC assessment. This process considers a myriad of factors, to include creating and refining a Modified Combined Obstacle Overlay (MCOO) that details avenues of approach, dangerous routes, closed bridges, flooded plains, enemy obstacles, and many other items relevant to movement to the target area.

(1) Select route, personnel, and use of subordinates.

(2) Determine method (e.g., route, aerial, map, vantage point).

c. Issue of order (notify subordinate leaders of time and place).

d. Coordination (adjacent and supporting units).

3. Make Reconnaissance.

a. Update METT-T.

b. Develop enemy's most probable course of action.

c. Confirm enemy's vulnerabilities.

4. Complete Plan.

a. Remember the concept of operations is driven by METT-T with an emphasis on mission (including intent) and the enemy's most probable course of action.

b. Develop scheme of maneuver to exploit enemy's vulnerability by placing him in a dilemma.

5. Issue Order.

Use the Five-Paragraph Order Format on page 5 (address the vantage point, use terrain modeling, use overlays, etc., if applicable).

6. Supervise.

Use brief backs, rehearsals, inspections, etc.

MCRP 3-11.1A **Commander's Tactical Handbook**
Troop Leading Steps **3** **Troop Leading Steps**

Figure 3. BAMCIS Outline from the MCRP 3–11.1A (continued from Figures 1 and 2). Source: USMC (1998a).

Security is always a concern as most reconnaissance units have to move long distances and cannot carry a lot of weaponry, and thus cannot defend themselves against larger enemy forces. Additionally, keeping one's primary mission a secret from the enemy becomes problematic if adversaries detect the reconnaissance activity during an intelligence gathering stage. Therefore, leaders must pay detailed attention to the covert status of the reconnaissance.

Once the recon is finished, the final stages of BAMCIS focus on completing the plan with the updated information, responding to last items and issuing the order to subordinate units. Depending on the size of the friendly unit, this can be a challenging task in and of itself, to ensure that the information passed to subordinates retains its integrity to avoid a misinterpretation of orders. Once the order is issued, participants will execute rehearsals and back-briefs to ensure accuracy, supervised by the leader.

2. LTA-2 Phases

The preliminary phases of LTA-2 consisted of the UAV and UGV conducting joint mapping of the entire area, the UAV with LIDAR. This imaging technology, that uses pulsed laser beams to collect image information (NOAA, 2016), was one of the unique attributes augmenting UTACC for the first time in this LTA. Simultaneously, the information enables possible route identification, presumably the job of the Marine working with the two unmanned systems to collect intelligence. This information may also provide detail sufficient to confirm the UGV route or develop an alternate route. Once the information is collected and sufficiently analyzed, the UGV will leverage this information to deploy into the target area, navigating by its newly produced map and searching for newly uploaded targets of interest.

This represents the execution of the mission for the evaluation scenario, where high-value targets move at random in the defined area. The UGV attempts to locate them using facial recognition software called Surveillance, Persistent Observation, and Target Recognition (SPOTR), produced by Progeny Systems (Progeny, 2016). If the UGV is successful in identifying the targets, this constitutes mission success and the UGV returns to base. If the UGV does not find the targets, then the UAV will automatically launch to provide aerial search assistance. This is the final phase of LTA-2, wherein the combined UGV/UAV search continues until target acquisition or until the vehicles exhaust their power. Table 3 outlines the phases of LTA-2 as presented to the authors.

Table 3. Preliminary Phases Used during UTACC Demonstration

Phases for LTA-2 - Quantico 2016
1. UAV maps (LIDAR) area + UGV maps (FR)
1.5 ID possible routes (Marine) (FR)
1.7 Confirm route good before deploying UGV (FR)
1.9 Develop Alt Route (FR)
2. UGV uses map to search for targets (multi tgts)
3. If 2 unsuccessful, use UAV to search
3. Was search successful (MOE)

Accounting for the relative immaturity of UTACC technology, this scenario allows for the capture of a remarkable amount of metrics that offer keen insight into the proficiency of the system at each stage of development. Additionally, this scenario allows for limited testing of the collaborative autonomy concept, which is just as much under development as the actual machines themselves.

3. UTACC MOP and MOE

MOPs and MOEs for UTACC cannot address human-based tactical tasks only. Doing so would ignore the fact that two-thirds of the UTACC team consists of machines wholly untested with emerging capabilities. The MOPs and MOEs must address machine performance as well. This means that specific UTACC tasks of data transfer, system monitoring, cyber defense, and many others must be included to ensure a thorough assessment of progress in a given scenario.

Beginning with each element of BAMCIS and focusing on which phase of LTA-2 most closely tied to that element, the authors were able to tie in tasks most relevant to the scenario in question, with focus on intelligence gathering activities, as prescribed by the ConOps. Table 4 is a synopsis of the primary tasks. The authors extracted and entered a myriad of sub-tasks into the matrix in association with each corresponding phase and troop-leading step.

Table 4. Preliminary UTACC MCTs of Interest. Source: USMC (2015b).

MCT	Description
2.2	Collect Data and Intelligence
2.2.1	Conduct Tactical Reconnaissance
2.2.3	Conduct Terrain Reconnaissance
2.2.5	Conduct Aviation Intelligence Collection Activities

Many tactical tasks came from MCTL 2.0, whereas most of the technical tasks spawned from the Coactive Design IA tables (Zach, 2016). In addition, the authors needed to create a new family of tactical and technical tasks with associated metrics to fill the gaps existing in current and emerging doctrine. The authors discuss the entire finished product in later chapters, as it involves accounting for Coactive Design, IA, live results from the LTA-2, and feedback from the UTACC development team. However, the three elements described in this section served as the critical first three layers in the UTACC MOP/MOE development analysis.

H. SECTION CONCLUSION

Establishing MOPs and MOEs for a brand-new concept such as UTACC is a daunting task, primarily because of the sheer volume of processes and tasks requiring assessment, as well as the dynamic nature of an emerging concept. To identify useful and enduring measures, certain assumptions emerge, such as the UTACC concept being technology agnostic. Additionally, UTACC is only beneficial if it does what it was intended to do: reduce the cognitive load on the human warfighter. This means that the MOPs and MOEs *must* tie directly into current mission and training standards extant in Marine Corps doctrine, and tailored to support increased proficiency and mission accomplishment. Finally, it must be recognized that despite the concept being technology agnostic, the development process will necessarily be demonstrated on current technological platforms, and certain machine-specific processes will need to be assessed for a complete understanding of progress. In the end, the MOP and MOE tables for

UTACC represent a complex interweaving of USMC doctrine, Coactive Design, M2M interdependency requirements, hardware and software capabilities, and task analysis.

IV. UTACC MOPS AND MOES

The generation of the initial MOPs and MOEs resulted in the capture of the comprehensive representation of Marine Corps Intelligence Operations. In general, developing MOPs and MOEs for any new program starts with a baseline of measures from similar programs, and develops from there, as opposed to starting from scratch every time. The lack of true “market comparable” examples to draw on greatly complicates creating MOPs and MOEs for an emerging technological concept. However, the emphasis placed on mission accomplishment within Marine Corps operations, along with the initial starting point of the main MCTL 2 primary tasks, provided a good hint at where to start developing metrics.

A. MCTL ORGANIZATION AND WARFIGHTING

The authors selected sub-tasks and associated metrics from the MCT “families” of 2.2–Collect Data and Intelligence; 2.2.1–Conduct Tactical Reconnaissance; 2.2.3–Conduct Terrain Reconnaissance; and 2.2.5–Conduct Aviation Intelligence Collection Activities, within the MCTL 2 publication. Metrics from within each of these MCTs emerged due to their applicable nature to the primary UTACC mission of intelligence gathering with ground and aerial-based sensors, as outlined by the UTACC CONOPS thesis (Rice et al., 2015). Sensors from the UGV and UAV would by nature fall under the task of Collect Data and Intelligence. The incorporation of a UTACC system within a small unit operating at the forward edge of the battlespace makes the Conduct Tactical Reconnaissance task applicable. Lastly, the CONOPS vision for the implementation of UTACC means that elements of both Terrain Reconnaissance and Aviation Intelligence Collection Activities would apply as metrics for a UTACC system.

Following the selection of MCT families from MCTL 2, it was necessary to consider the units of measurements for the resulting metric categories. Suitably, a majority of the subtask metrics listed in the MCTL for Intelligence Operations already include a unit of measurement for the existing doctrinal tasks metrics. The detailed nature of MCTLs as refined over generations of Marine Corps warfighting activity provided confidence that the units of measurement were appropriate for their respective tasks and sub-tasks. Table 5 shows an initial selection of metrics taken from within the above families of MCTs, along with the codes “M1,”“M2,” etc. providing a unit of measurement. It also shows a description of the respective metric to the right of the table.

Table 5. Initial Selection of Metrics from within MCTL 2 Task Families.

2.2.1.2	**Conduct Area Reconnaissance**	M1	0.2	Hrs	From receipt of tasking, unit reconnaissance assets in place.
2.2.1.2	**Conduct Area Reconnaissance**	M2	Y	Y/N	Provide photographic and descriptive data of the Named Area of Interest to the Commander and staff.
2.2.1.2	**Conduct Area Reconnaissance**	M4	5	Hrs	To conduct reconnaissance before movement of main body.
2.2.1.3	**Conduct Zone Reconnaissance**	M1	0.5	Hrs	From receipt of tasking, unit reconnaissance assets in place.
2.2.1.3	**Conduct Zone Reconnaissance**	M2	N	Y/N	Provide photographic and descriptive data of the Named Area of Interest (NAI) to the Commander and staff.
2.2.1.3	**Conduct Zone Reconnaissance**	M12	2	Hrs	To conduct reconnaissance before movement of main body.
2.2.5.2	**Conduct Aviation Reconnaissance**	M3	34	%	Of equipment ready and available to provide air reconnaissance operations.
2.2.5.2	**Conduct Aviation Reconnaissance**	M4	Y	Y/N	Product (sensor) dissemination/distribution network available.
2.2.5.2	**Conduct Aviation Reconnaissance**	M7	N	Y/N	Able to communicate relevant reconnaissance information using line-of-site (LOS)/beyond-line-of-site (BLOS) means.
2.7	**Conduct Ground Reconnaissance and Surveillance**	M2	45	%	Of equipment ready and available to provide reconnaissance and surveillance operations (i.e., communications, target designation, crew served weapons, infiltration/exfiltration equipment, mobility assets).
2.7	**Conduct Ground Reconnaissance and Surveillance**	M3	Y	Y/N	Capable of conducting ground reconnaissance and surveillance across the MAGTF Commander’s area of influen
2.7	**Conduct Ground Reconnaissance and Surveillance**	M4	1	Hrs	From receipt of tasking, unit reconnaissance/surveillance assets in place.
2.7	**Conduct Ground Reconnaissance and Surveillance**	M5	70	%	Of collection requirements fulfilled by reconnaissance/surveillance assets.

For each of the sub-task metrics within the Task Families, a specific task description helps depict what the actual activity and metric might looks like in a tactical warfighting scenario. For example, the MCT 2.2.1.2 with metric M2 describes the requirement to “Provide photographic and descriptive data of the Named Area of Interest to the Commander and staff” (MCTL 2). One can envision in a tactical scenario exactly what a Named Area of Interest (NAI) might be for a small recon unit commander, such as a bridge or crossroads along a major Line of Communication. If a UTACC system deployed in a scenario like this, the task of taking a photo of said NAI and immediately displaying it to the unit commander would be an easy feat, and the metric result would be “Y.” Therefore, this metric would qualify as applicable for UTACC. The authors conducted such an evaluation of every metric within the MCTL 2 MCTs to select candidate metrics for becoming UTACC MOPs and MOEs.

These initial selections of relevant subtask metrics for the UTACC mission was further refined into what would be suggested as MOPs and MOEs for the UTACC LTA to come, as addressed in subsequent discussion.

B. MOPS

The authors resolved that the concept of "Performance" could apply to any activity with documentation of a metric. For instance, either proactive sensors calculating mileage per fuel volume consumed or retroactive calculation of economy as a function of total mileage achieved over fuel volume consumed documents the fuel-economy performance of a car. These methods provide a MOP about how the car operated, but will tell you neither if the car reached its intended destination nor if it delivered all intended passengers and cargo.

In this respect, MOPs are no more complicated than a yardstick applied to the activity at hand, devoid of any deeper echelon of analysis. All that is required is a unit of measurement and a tool with which to measure. In Table 6, excerpts from the MCTL 2 publication give an example of these units of measurement for Scenario 1 of LTA–2, such as percentage completion and time for task accomplishment measured in hours.

Table 6. MCTL 2 Task Descriptions and Units of Measurement

1	Jointly Produce Map				
MCT	MCT Description	MOP	Result	Unit	Description
2.2.1.2	Conduct Area Reconnaissance	M1	0.2	Hrs	From receipt of tasking, unit reconnaissance assets in place.
2.2.1.3	Conduct Zone Reconnaissance	M1	0.5	Hrs	From receipt of tasking, unit reconnaissance assets in place.
2.2.5.2	Conduct Aviation Reconnaissance	M3	34	%	Of equipment ready and available to provide air reconnaissance operations.
2.7	Conduct Ground Reconnaissance and Surveillance	M2	45	%	Of equipment ready and available to provide reconnaissance and surveillance operations
2.7	Conduct Ground Reconnaissance and Surveillance	M4	1	Hrs	From receipt of tasking, unit reconnaissance/surveillance assets in place.
2.7	Conduct Ground Reconnaissance and Surveillance	M5	70	%	Of collection requirements fulfilled by reconnaissance/surveillance assets.

Other metrics taken from subtasks of MCTL 2 would amount to relatively objective questions with binary answers of "Y" for yes and "N" for no, as shown and highlighted in Table 7. Despite the relatively objective nature of these questions, refined over the years by subject matter expert authors of Marine Corps doctrine, the binary responses to these determination questions would rely on judgment of the UTACC program evaluators in conjunction with program office elements from the MCWL.

Table 7. MCTL 2.2 Task Descriptions and Binary Accomplishment Status

1	Jointly Produce Map				
MCT	MCT Description	MOP	Result	Unit	Description
2.2.1.2	Conduct Area Reconnaissance	M2	Y	Y/N	Provide photographic and descriptive data of the Named Area of Interest to the Commander and staff.
2.2.1.3	Conduct Zone Reconnaissance	M2	N	Y/N	Provide photographic and descriptive data of the Named Area of Interest (NAI) to the Commander and staff.
2.2.5.2	Conduct Aviation Reconnaissance	M4	Y	Y/N	Product (sensor) dissemination/distribution network available.
2.2.5.2	Conduct Aviation Reconnaissance	M7	N	Y/N	Able to communicate relevant reconnaissance information using line-of-site (LOS)/beyond-line-of-site (BLOS) means.

What is lacking from the MCTL is the threshold of acceptable performance. Subsequently, no comparable from the MCTL exists for incorporation or inspiration for developing UTACC MOP thresholds as well. The existing MOP "results" and threshold coloration in Appendices A are notional examples of what desired performance levels might look like with respect to the unit of measurement given for that metric. In the case of UTACC, MCWL is the ideal organization to determine initial thresholds for success. MCWL can then easily refine these thresholds through subsequent experimentation further along the acquisitions life cycle.

C. MOES

The ultimate goal for developing any system or technology in conjunction with a DOD acquisitions process is to connect that system's capabilities with accomplishing a mission. During the analysis of the MCTL-2 subtasks related to the proposed UTACC LTA-2 scenarios, it became apparent that a limited number of metrics of each MCTL were adoptable as Measures of Effectiveness. Table 8 highlights two of the primary examples of such metrics.

Table 8. MCTL 2 Metrics Adopted as Suggested MOEs. Source: Marines (2015)

2	Target Only Visible to UGV				
2.2	Collect Data and Intelligence	M1	25	%	Of targets accurately identified.
2.2	Collect Data and Intelligence	M2	25	%	Of targets accurately located.

The Table 8 metrics taken from MCTL 2 equate to the concept of mission accomplishment within the realm of the UTACC scenario. The authors adopted them as appropriate MOPs or rough equivalents that would constitute mission success for the given scenario. These same two sub-metrics of 2.2 M1 and 2.2 M2 (belonging to the higher echelon MCTL 2.2 series task metrics) viewed across multiple sub-tasks of MCTL 2, would generally apply to many scenarios and missions involving intelligence gathering efforts. This was due to their applicability for any scenario involving targets located and identified, which was the desired end state for the UTACC scenarios.

D. LTA–2 PROPOSED SCENARIO METRICS

From the initial LTA–2 planning efforts, seven scenarios were planned for evaluating UTACC following the performance evaluation from LTA efforts the year before. These scenarios were Jointly Produce Map; Jointly Produce Map of Alternate Environment; Target Only Visible to UGV; Target Only Visible to UAV; Target Not Present; Only Incorrect Targets Present; Both Correct and Incorrect Targets Present; and Start Hunt for Target at Suspected Location. For each of these scenarios, the thesis team developed grade sheets and a list of MOPs to associate for each scenario. These grade sheets incorporated best practices brought from the authors' previous experience in exercise evaluation at the Marine Air Ground Combat Center (MAGCC) Twentynine Palms. The evaluators of the Tactical Training Exercise Control Group regularly employ such grade sheets at MAGCC to evaluate the MET proficiency of USMC units during pre-deployment work up exercises (TTECG 2016).

As the LTA-2 testing plan and actual labeling of the scenarios fluctuated, the grade sheets and MOP lists were slightly refined. However, the underlying suggested metrics largely remained the same or similar. This was due to the similar nature of each scenario and the group of MCTL-based MOPs that applied across the board to most of the scenarios. The final products of both the list of MOPs and grade sheets constitute Appendices A and B, respectively, with an example of grade sheet in the form of Scenario 1 shown in Table 9.

Table 9. Excerpt of Scenario 1 Grade Sheet for LTA–2

Scenario 1 – Jointly Produce Map								
MCT	MCT Description	MOP	Result	Unit	Grade L M H			Comments
UTACC 1.2	Enter Mission Parameters	M1		%				
UTACC 1.2	Enter Mission Parameters	M2		%				
UTACC 1.2	Enter Mission Parameters	M3		%				
UTACC 1.2	Enter Mission Parameters	M4		%				
UTACC 1.2	Enter Mission Parameters	M5		%				
2.2.1.2	Conduct Area Reconnaissance	M1		Hrs				
2.2.1.2	Conduct Area Reconnaissance	M2		Y/N				
2.2.1.3	Conduct Zone Reconnaissance	M1		Hrs				
2.2.1.3	Conduct Zone Reconnaissance	M2		Y/N				
2.2.5.2	Conduct Aviation Reconnaissance	M3		%				
2.2.5.2	Conduct Aviation Reconnaissance	M4		Y/N				

Arming MCWL with the grade sheets and MOP lists from the thesis team ahead of time allowed the LTA-2 testing plan to incorporate an element of Marine Corps doctrine.

E. LTA ENVIRONMENT

Given the desired scenarios, it was necessary to create a unique assessment environment in which MCWL could evaluate the proposed metrics. For example, the combination of ground and aerial sensors involved necessitated having the effect of a multi-storied urban facility so that the evaluators could recognized the UTACC system's ability to share data through its UTACC software and self-guide the sensor platforms to blind spots in the environment. Accordingly, MCWL assembled a mock urban village with multi-storied cardboard buildings so that UTACC would recognize blind spots in the environment and cooperatively plan to move to those areas with the appropriate sensor platform to accomplish the desired task. Figure 4 depicts the initial mock village and terrain model MCWL used for LTA–2 environment to this end. As shown, the environment included not only buildings for target searching but also mock trees and navigation obstacles such as a notional river with limited crossing areas, to test the UGV's ability to navigate and communicate the obstacles to other elements of UTACC through various software functions.

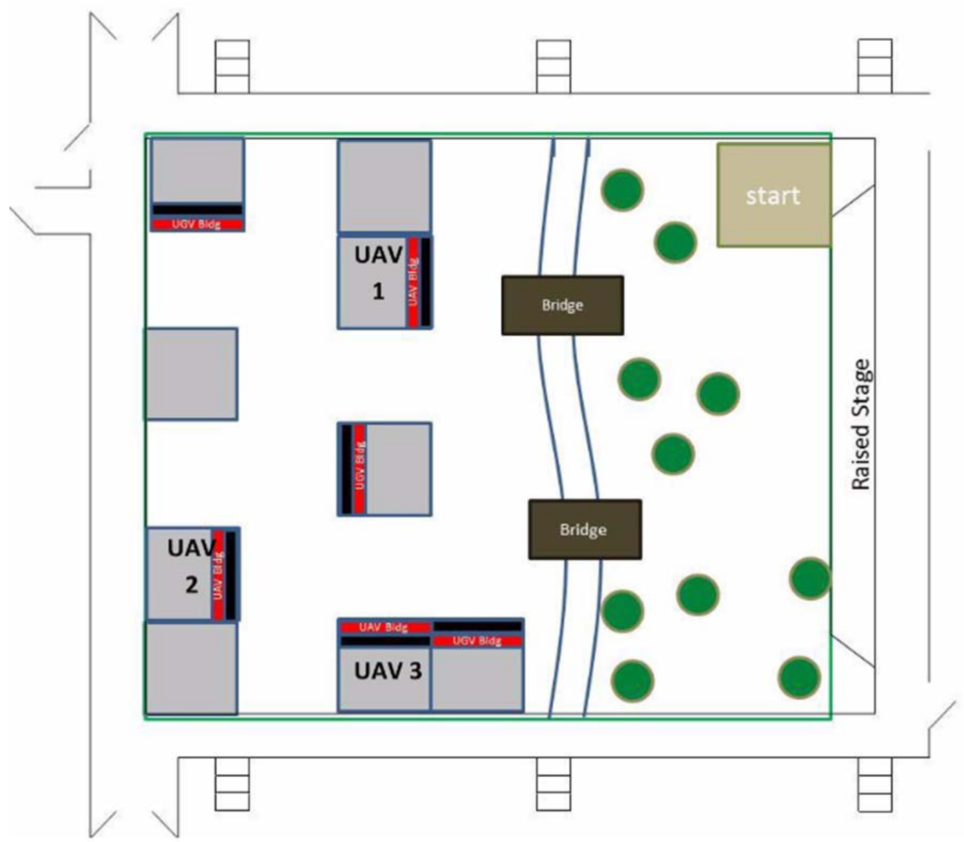

Figure 4. MCWL Mock Village Design for LTA–2 Scenario 1

In most of the scenarios for LTA–2, the desired end state centered largely on gathering data points from the various sensors to develop information about the environment. As the testing scenarios progressed, MCWL evaluators would change the arrangement of the mock village buildings and obstacles to re-set data point baselines and test UTACC's ability to map the area from scratch each time. This capability is one of the unique strengths of UTACC, as its ability to process and merge multiple data sensor sources constituted a progression of UTACC team understanding of the environment from “data” to “information.” This dynamic practice of information sharing essentially amounts to semi-autonomous knowledge management as introduced by Professor Nicholas Henry in 1974 (Henry, 1974). This robust form of information exchange between UTACC team members can only improve and expand as opportunities for subsequent LTAs and evaluations occur.

F. SECTION CONCLUSION

Bifurcating and associating existing metrics from the MCTL 2 publications was not necessarily an exhaustive effort in terms of UTACC application for Marine Corps Operations. Given that the effort centered on intelligence operations appropriate from the UTACC CONOPS depiction, there are still numerous doctrinal metrics applicable for future UTACC testing events. However, it was apparent that the application of vetted MCTL 2 metrics and units of measurement to the UTACC LTA-2 was a success for proposing a starting point for developing MOP. The methodology of adopting MCTL metrics as MOP is an applicable approach to additional MCTL for other warfighting functions and mission areas.

The refinement of proposed MOE and success thresholds will likely need to incorporate additional input from both the owning USMC agency and from additional MCTLs. In addition to facilitating further LTAs and evaluations, these additions will further legitimize the UTACC program as applied to all aspects of the USMC functional warfighting areas outlined in EF21.

V. FEEDBACK AND REFINEMENT

A. INTRODUCTION

LTA-2 served as a critical stepping-stone for further development of the UTACC concept. The primary focus of LTA-2 was on testing and developing software algorithms used to execute missions with human teammates, as well as myriad technical processes involved in merely operating technologically complex systems. The challenge to the authors became finding a way to merge high-level MOPs with the technical necessities of the LTA. In order to serve as a useful framework for quantifying proficiency and effectiveness once the UTACC system is fully integrated into the fleet, the MOPs must focus on tactical mission accomplishment while allowing for the inclusion of software and technology-specific metrics to be added as they become relevant. This necessity became readily apparent during the conduct of LTA-2, and it drove the authors to create a three-level system for how to integrate each type of MOP and MOE into UTACC development. The authors discuss this in detail in the "Merging the Metrics" section of this chapter.

B. AFTER ACTION REVIEW

The inherent value in any effective demonstration or experiment rests in much more than just the conduct of the exercise. Information gleaned during the exercise must be organized, discussed, and disseminated to effect program improvement. The most common method in the military for accomplishing this is by conducting an after action review (AAR). According to Global Security (2016), an AAR is "A verbal, professional discussion of a unit's actions that typically occurs immediately after a training event, combat operation, or other mission that determines what should have happened, what actually happened, what worked, what did not work and why, and the key procedures a unit wants to sustain or improve."

An AAR is more than just a recitation of facts and observations of the events that unfolded during the exercise; it represents the synergistic merger of professional analysis from myriad perspectives, many of them with decades of experience in their field. During the AAR at Quantico immediately following the conclusion of LTA-2, representatives from multitude of agencies convened to debrief. This included personnel from MCWL, Dahlgren, CMU, Air Force Research Laboratory, Progeny Systems, Sierra Nevada Corporation, NPS, Visumpoint, and CNA. These personnel provided observations, analysis and recommendations for improvements for the program in preparation for LTA-3, which is scheduled for February 2017 (Nachem, 2016).

Each member of the UTACC development team weighed in on the separate areas of concern, which ranged from formalization of the programmatic requirements to testing of the UTACC software. For the purpose of this thesis, we will only focus on the feedback that directly affected development of MOPs and MOEs. Chief among the recommendations that emerged from the AAR was an increased focus on the interdependence between human and machine, which had a direct impact on MOP and MOE development. Additionally, MCWL called for a more explicit integration of BAMCIS into UTACC mission planning, which worked well with the research methodology adopted by the authors early on, but required additional analytical rigor to fuse each task more closely with each sub-element of the planning process. The most dramatic and actionable lesson learned from LTA-2, however, was the necessity to include scenario-specific technical metrics into the MOP/MOE development effort.

C. TECHNICAL METRICS FOR LTA-2

The purpose of a Limited Technical Assessment, as the name suggests, is to observe a huge range of technical parameters and processes in order to test software algorithms, technical systems, power requirements, and so forth. In order to accomplish this, MCWL personnel working closely with CNA and CMU representatives developed a series of metrics that focused primarily on the internal functions and technical applications needed to complete the LTA. Each of the different scenarios required its own specific set of tasks to accomplish different elements of the mission, and so MCWL created individual task lists for each of the eight scenarios. Table 10 is a snapshot of one of the scenario checklists.

Table 10. Scenario 1–Jointly Produced Map, MCWL Worksheet for LTA-2 Evaluation

Scenario: 1 Run # (circle): 1 2 3 4 5 Observer:________________ Date:________

Mission Type: Map/Reconnaissance

Task #	Time Issued	Command/Event	S	F	Notes/Observations [Issues, Clarifications, or Other Observations]
2.		Ability to manipulate map (Zoom in/out, Pan left/right, North Up/Vehicle Up) for view and use in UI. Note 1.2: this functionality is not yet present but is expected in a future release.			
3.		Ability to geo-rectify (set scale, tie to GPS point or points, and provide north) map data for view and use in UI. Note 1.3: this functionality is not yet present but is expected in a future release.			
4.		Operator able to designate entire area as AOI in overview map imported in step 1			
5.		Operator ability to designate sub-area(s) as AOI(s) Note 1.4: this functionality is not yet present but is expected in a future release.			
6.		Ability to select Map mission in UI			
7.		Ability to execute Map mission			
8.		UGV produces map within AOI			
9.		UGV Stays within AOI			
10.		UGV accurately recognizes if it cannot complete mission, and alerts operator			

Reading down this list of low-level but highly technical tasks reveals the necessity of measuring these functions at an LTA, while simultaneously illuminating the reason they should not be included in the final MOP/MOE publication for UTACC systems; they are necessary developmental measurements of functions whose efficacy will be a foregone conclusion in an operational system. Take for instance task six (Ability to select Map mission in UI). Considering that LTA-2 was the first time all of the separate components of UTACC have been brought together in a tactical scenario, the critical task of being able to select the appropriate mission in the application cannot be taken for granted; it may not work during the test. Similarly, many other areas of functionality, to include power, connectivity, data transfer, compatibility between disparate camera, drone and facial recognition technologies, and many more all need to be tested and improved in order to advance to the next stage of UTACC development.

The Appendix A is full list of metrics created for LTA-2, and provides powerful insight into the development process for a groundbreaking concept like UTACC. A similar list of metrics should provide for future LTAs a focus on higher order functions of the human/machine team and should account for the latest developments in robotic technological capabilities. As the LTAs progress, a natural evolution will occur with what metrics need to be actively measured and which can be relegated to the category of "automatic processes" which run in the background and are highly reliable.

The analogy of an automobile works well in this situation. When a research and development team designs a car, they measure everything from the efficiency of the fuel injection system to the amount of electricity produced by the alternator. However, once the system is operational the driver does not care about the automatic systems that operate in the background to keep the vehicle running, they only care about the performance characteristics, such as how quickly the vehicle goes from zero to 60 miles per hour, or how well it hugs the road during a high-speed turn. Thus, as the program matures, the metrics that dominate the conversation change, just as in the case of UTACC. As UTACC progresses forward, the assessed metrics will shift from lower level technological processes to interdependencies between machines, then to interdependencies between machines and humans, and finally to tactical task accomplishment by the UTACC team as a whole. This evolution, and the necessity of each phase of assessment metrics, served as the impetus behind the authors' creation of a three-level amalgamation of all necessary measures of performance and effectiveness, discussed in the following section.

D. MERGING THE METRICS

As stated above, the metrics used principally to measure the technical progress of CMU algorithms, Progeny SPOTR cameras, UTACC software, etc., required creation and integration into LTA-2 to allow for further development of the UTACC concept. However, many of these MOPs and MOEs will be transparent to the Marine on the battlefield upon integration of this system into the operating forces, whose main concern will be mission accomplishment. To address the evolutionary nature of which metrics are most relevant at any given time, the authors created a three-level system for identifying the most appropriate MOPs for each phase of UTACC development.

MCWL already created the first layer for LTA-2, and including tasks outlined in the aforementioned task worksheets. Tasks within Level 1 constitute technical and scenario-specific MOPs (e.g., Ability to select Map mission in UI, UGV produces map within AOI) that will serve as an initial level of metrics for measuring growth and performance in the UTACC system. This level represents the baseline layer of metrics requiring measurement, literally on the same level as algorithm and code development. The purpose of designating the first level as such allows not only system designers and program developers to be on the same page when deciding progress, but it also creates a blueprint for future program development from a conceptual to operational level.

The second level of metrics includes incorporating Marine teammates into the scenario and accounting for the interdependence between the humans and machines. This will be further developed and tested in the next LTA (e.g., Enter Mission Parameters, Provide for Security, Conduct Reconnaissance before movement of main body, Conduct analysis of intelligence gathered during reconnaissance). Although these levels can coincide with certain LTAs, they tend to blend as UTACC capabilities grow. For instance, although the majority of tasks measured during LTA-2 were Level 1 tasks, a significant number also fit into the definition of Level 2 level tasks, as illustrated in Table 11, which is a snapshot of a Task Worksheet created for the final scenario of the LTA.

Table 11. Scenario 8–Start Hunt for Target at Suspected Location, MCWL Worksheet for LTA-2 Evaluation

Scenario: 8 Run # (circle): 1 2 3 4 5 Observer:____________________ Date:_________

Mission Type: Target Acquisition

Task #	Time Issued	Command/Event	S	F	Notes/Observations [Issues, Clarifications, or Other Observations]
1.		Operator able to designate entire area as AOI in overview map.			
2.		Operator able to designate sub-area(s) as AOI(s) Note 8.1: this functionality is not yet present but is expected in a future release.			
3.		User able to add OOIs & POIs			# POI Added_____ # OOI Added_____
4.		Ability to select Find mission in UI			
5.		Ability to execute Find mission			
6.		prompts user with the yes/no option to designate a suspected location within the AoI to head to first, and further presents the option to designate this via either touch or GPS coordinates. Note 8.2: this functionality is not yet present but is expected in a future release.			
7.		plans most direct path to the suspected location and displays this to the Operator; Note 8.3: this functionality is not yet present but is expected in a future release.			
8.		allows Operator to force a replan to the suspected location by designating no-go locations; Note 8.4: this functionality is not yet present but is expected in a future release.			

Notice the interaction between the robot and the human teammate, particularly in tasks 10, 12, and 17–20. These tasks measure the level of interdependence between teammates, as well as the efficacy of the interaction, which is clearly a Level 2 type of metric but fits into the capabilities expected of UTACC during LTA-2. As UTACC moves to LTA-3, many of the Level 1 metrics will remain relevant. However, as the team works out system bugs, any metrics that measure minor functionality, such as the ability to zoom in and out on the map, will fall away and new Level 2 metrics will emerge.

The third and final level of metrics will be inclusive of the lower levels and represent a comprehensive set of measures of the performance of UTACC in its entirety. This will include Human/Machine interaction and interdependence, and the mission planning aspects addressed in the near future (e.g., Develop Mission Profiles, Refine Mission Profiles, Issue order to Subordinates, Submit to HHQ for Approval). The third level focuses primarily on the higher level MOPs and MOEs outlined in Chapter IV of this thesis, and allows for assessment and quantifying not only the sub-processes of UTACC, but also the effectiveness of the system as a teammate in a live tactical scenario. Those Level 3 MOPS and MOEs serve as the primary reference for TTECG exercise controllers evaluating UTACC-enhanced Marine reconnaissance units as they conduct Integrated Training Exercises at the MAGCC. Prior to that, UTACC planners will incorporate certain segments of the MOP tables into LTA-4 and LTA-5, to serve as preparation for a live-force experiment run by MCWL sometime in mid-2019 (Nachem, 2016). Table 12 provides an illustration of how all the metrics merge at Level 3 to provide a table that an exercise controller can use to quantify how successfully the entire UTACC team performed during each phase of the exercise.

Table 12. Thesis Authors' MCT Table Excerpt with MOPs

BAMCIS	Phase Description	MCT	MCT Description	MOP	Result	Units	MOP Description
Begin Planning	**Initialize System/Set Preferences + Enter Mission Parameters**	**UTACC 1.1**	**Set the Desired Level of Autonomy**	M1	H	L/M/H	Define the general nature of each H-M relationship and understand the role within each level
		UTACC 1.2	**Enter Mission Parameters**	M1	75	%	Input Orientation: Upload the present location, direction of attack and objective, and known key terrain data
		UTACC 1.2	**Enter Mission Parameters**	M2	80	%	Situation: Contains information on enemy (which will include SALUTE, DRAW-D, EMLCOA and EMDCOA) and friendly (which includes locations and missions of higher, adjacent and supporting units)
		UTACC 1.2	**Enter Mission Parameters**	M3	55	%	Mission: Upload the UxV's mission as related to the mission of the team (Who, What, When, Where, Why). Include tactical tasks.
		UTACC 1.2	**Enter Mission Parameters**	M4	60	%	Execution: Upload Concept of Operations (Commander's Intent, Scheme of Maneuver, Fire Support Plan), Tasks and Coordinating Instructions
		UTACC 1.2	**Enter Mission Parameters**	M5	67	%	Admin and Logistics: Define number and roles of humans and robots collaborating in team environment, and establish refueling and RTB points if different from origin
		UTACC 1.2	**Enter Mission Parameters**	M6	99	%	Command and Signal Plan: Upload Command, Signal, Retransmit and Comm Plans
	UAV maps (LIDAR) area + UGV maps (FR)/Select Emphasis Area	**2.2.1.2**	**Conduct Area Reconnaissance**	M1	0.2	Hrs	From receipt of tasking, unit reconnaissance assets in place.
		2.2.1.2	**Conduct Area Reconnaissance**	M2	Y	Y/N	Provide photographic and descriptive data of the Named Area of Interest to the Commander and staff.
		2.2.1.2	**Conduct Area Reconnaissance**	M4	5	Hrs	To conduct reconnaissance before movement of main body.
		2.2.1.3	**Conduct Zone Reconnaissance**	M1	0.5	Hrs	From receipt of tasking, unit reconnaissance assets in place.
		2.2.1.3	**Conduct Zone Reconnaissance**	M2	N	Y/N	Provide photographic and descriptive data of the Named Area of Interest (NAI) to the Commander and staff.
		2.2.1.3	**Conduct Zone Reconnaissance**	M12	2	Hrs	To conduct reconnaissance before movement of main body.
		2.2.5.2	**Conduct Aviation Reconnaissance**	M3	34	%	Of equipment ready and available to provide air reconnaissance operations.
		2.2.5.2	**Conduct Aviation Reconnaissance**	M4	Y	Y/N	Product (sensor) dissemination/distribution network available.
		2.2.5.2	**Conduct Aviation Reconnaissance**	M7	N	Y/N	Able to communicate relevant reconnaissance information using line-of-site (LOS)/beyond-line-of-site (BLOS) means.
		2.7	**Conduct Ground Reconnaissance and Surveillance**	M2	45	%	Of equipment ready and available to provide reconnaissance and surveillance operations (i.e., communications, target designation, crew served weapons, infiltration/exfiltration equipment, mobility assets).
		2.7	**Conduct Ground Reconnaissance and Surveillance**	M3	Y	Y/N	Capable of conducting ground reconnaissance and surveillance across the MAGTF Commander's area of influen
		2.7	**Conduct Ground Reconnaissance and Surveillance**	M4	1	Hrs	From receipt of tasking, unit reconnaissance/surveillance assets in place.
		2.7	**Conduct Ground Reconnaissance and Surveillance**	M5	70	%	Of collection requirements fulfilled by reconnaissance/surveillance assets.
		UTACC 2.1	**Conduct Initial Mapping - Depart Friendly Lines**	M1	Y	Y/N	Resolve airspace deconfliction and meet safety threshhold for launch.

E. SECTION CONCLUSION

The most effective way to view UTACC program development is to look at it like training a new USMC recruit. The first step is to develop basic skills manageable with an untrained person, such as monitoring water consumption while performing physically demanding tasks. The intuitive response is to assume that the average person would be able to recognize the need for water and consume an appropriate amount, but the staggering amount of dehydration cases in new recruits shatters that assumption quickly. For UTACC, early stages of development bring challenges including the ability of batteries to hold a charge, software programs to run properly, or even reliable network connectivity. UTACC planners must take great care to assess each process so progress can occur.

Once a new recruit learns basic skills and has the ability to function at a basic military level, he or she learns to work with a team and respond appropriately when orders are given. The instructors give the recruit a small amount of autonomy to complete certain tasks with minimal supervision, but overall the recruit remains on a short leash. Similarly, with UTACC, the second level of metrics includes tasks that require interdependency with human teammates, ability to operate in a simulated environment with certain amounts of autonomy, and minimal supervision.

The final stage of development, which corresponds to Level 3 of MOPs and MOEs, is when the recruit becomes a trusted squad member, and handlers grant the recruit a commensurate level of responsibility and autonomy. For UTACC this corresponds to full operational capability. There the unmanned systems not only perform their specified tasks effectively, but also have the ability to operate without supervision for significant periods, leaving the humans to focus their attention elsewhere.

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VI. SUMMARIZING RESULTS AND RECOMMENDATIONS FOR FURTHER RESEARCH

A. INTRODUCTION

The primary purpose of this thesis was to establish a table of quantifiable metrics that take into account not just the development efforts of the UTACC concept. It also anticipates future assessment requirements for a system in a tactical scenario.

B. SUMMARIZING RESULTS

The final thesis product pulled together ideas and elements from MCT 2, UTACC IA Tables (Zach, 2016), Marine Corps Troop Leading Steps (USMC, 1998a), LTA-2 (Nachem, 2016) and NPS subject matter experts to create the final set of UTACC MOP/MOE tables found in Appendix A. While any method for measuring proficiency can and should be continually evaluated itself so that it can improve over time, it is the authors' fervent hope that this table will provide an effective baseline for understanding and evaluating the capabilities and limitations of this exciting new warfare concept.

1. MOP/MOE Final Tables

The final MOP/MOE tables for intelligence gathering with UTACC have the benefit of simultaneously addressing the higher-level requirements of a multi-level, multi-phased intelligence gathering tactical scenario. It also offers the ability to identify specific sub-processes during a given phase, singled out for further analysis. With the added benefit of lessons learned during LTA-2, UTACC members can now use the updated tables during Level 1 or Level 2 of the UTACC concept development process as well. This document can be taken by exercise planners and used to create scenarios for UTACC that reflect simulated combat conditions, while also operating within a framework of potential anticipated actions measured for proficiency. Exercise controllers can also turn it into a grading sheet that allows a Lance Corporal walking alongside the exercise force to rate how well UTACC performed the tasks. Table 13 illustrates the possibility of this process.

Table 13. MCT Table Excerpt with Both MCT and New UTACC MOPs

Arrange/ Make Recon	**ID Possible Route (Marine) (FR)**	**2.2.1.1**	**Conduct Route Reconnaissance**	M4	1	Hrs	To conduct initial route study (dismounted/mounted).
		2.2.1.2	**Conduct Area Reconnaissance**	M15	70	%	Of obstacles on movement routes identified before they can impede or halt movement of main body.
		2.2.1.2	**Conduct Area Reconnaissance**	M18	25	%	Of obstacles astride the route identified by reconnaissance prior to arrival of main body.
		2.2.3	**Conduct Terrain Reconnaissance**	M1	1	Hrs	From receipt of tasking, unit reconnaissance assets in place.
		2.2.3	**Conduct Terrain Reconnaissance**	M2	Y	Y/N	Provide photographic and descriptive data of the urban terrain to the Commander and staff.
		2.2.3	**Conduct Terrain Reconnaissance**	M4	2	Hrs	To conduct reconnaissance before movement of main body.
		UTACC 3.1	**Conduct Detailed Mapping**	M1	70	%	Scan Emphasis Areas. Execute detailed mapping protocol (the protocol will be different for why we selected the area for additional emphasis) ie. If for LZ, execute the LZ protocol, if for route then etc. Build detailed map collaboratively.
		UTACC 3.1	**Conduct Detailed Mapping**	M2	Y	Y/N	Alert Team to Relevant Info.Transmit map information relevant to mission
		UTACC 3.1	**Conduct Detailed Mapping**	M3	Y	Y/N	Notify When Near Completion. Alert Marine when planning threshold is hit.
		UTACC 3.1	**Conduct Detailed Mapping**	M4	25	%	Monitor System Health. Understand when to return for maintenance or refueling
		UTACC 3.2	**MCOO**	M1	25	%	Depict Vegetation. Depict type of vegetation, tree spacing, trunk diameter, soil types, and conditions that affect mobility.
		UTACC 3.2	**MCOO**	M2	25	%	Depict Surface Drainage. Depict water sources (width, depth, velocity, bank slope, height, and potential flood zones)
		UTACC 3.2	**MCOO**	M3	25	%	Depict All Other Effects. Depict surface configuration (elevation, slopes that affect mobility, line of sight for equipment usage. Depict obstacles, natural and manmade. Transportation systems (bridge classification and road characteristics such as curve radius, slopes, and width)
		UTACC 3.2	**MCOO**	M4	25	%	Depict Combined Obstacles. Depict terrain (severely restricted, restricted and unrestricted)
		UTACC 3.2	**MCOO**	M5	25	%	Depict Mobility Corridors and Avenues of Approach. Mobility corridors are that area within an AA that allows a particular sized unit to deploy and maneuver in its doctrinal, tactial formation. The corridors depicted by UTACC should correspond to the most common unit that will be deployed in the proposed mission sets. Avenues of Approach should encompass the Main Effort, Supporting Effort and the Air Avenue of Approach and should be depicted from estimated start point to proposed objective.

In the Fleet Marine Force, a planning officer will take the annotated MCT Table and begin by identifying that this particular section of the MOP/MOE table addresses the Arrange and Make Reconnaissance portion of BAMCIS. He or she will then note that within that portion of BAMCIS this phase of the operation will deal primarily with identification of a possible route to the Named Area of Interest (NAI), which will include both use of the Marine and use of the feature recognition technology (FR) within UTACC. The next step will include annotating which MCT they want to examine, for instance perhaps they want to focus on how well UTACC develops a Modified Combined Obstacle Overlay (MCOO), which would fall within the section of MCTs under the designation "UTACC 3.2."

At this point, the planner could determine an actual MOP within the UTACC 3.2 MCT designation. There are five MOPs under UTACC 3.2, and they correspond to the MCOO sub-tasks within the UTACC IA Tables (Zach, 2016), which makes for an effective interdependence analysis as well as being useful as an MOP in a tactical scenario. Once a final MOP emerges, the planner can then set a threshold for what level of completion of the MOP denotes success for a particular task. In the instance of M1 (Depict Vegetation) the unit designated is percentage of the specified area, which means that in order to achieve 100%, every square foot of the specified area needs to be detailed by the UTACC system with regards to vegetation, tree spacing, soil types, and any other major aspect of vegetation that will interfere with mobility. It is now up to the planner to determine if 100% is necessary for mission completion or if a lesser amount will still allow the unit to move through the area with relative effectiveness.

This type of analysis by the planner may take days or merely seconds, depending on the level of importance of that particular task to the mission. However, once the threshold for success has been set, planners may then transcribe the MOP onto a grading worksheet and give it to an exercise controller, who will observe the actual UTACC team in action during a tactical exercise. By examining the computer output detailing the map completion percentage concerning vegetation, the controller may then annotate the percentage down on his or her worksheet, and submit it to higher headquarters for analysis and recommendations for further training. This is one small example of how these MOP/MOE tables may prove useful to integrate and enhance the effectiveness of UTACC in intelligence gathering missions or eventually multi-faceted kinetic combat operations.

2. Limitations of MOP/MOE Tables

Regardless of how much intellectual rigor goes into creating a comprehensive list of potential future metrics, it is impossible to foresee every possible task assessed when UTACC finally hits the fleet. For every considered permutation in the projected scenarios, the amount of associated MOPs grow exponentially. Thus, in order to maintain a manageable source document, the process forced the authors to limit their imaginations to most likely and most productive tasks. These tasks were then included in the MOP/MOE table. Ideally, as UTACC becomes more mature and more capable, the list of MOP/MOEs will explode, freeing up the cognitive load of the Marine warfighter while simultaneously mitigating nearly all danger to the humans involved in the operation.

The authors took great pains to remain as generic as possible concerning specific technology while tailoring the MOP parameters to allow for the enhanced potential capabilities of UTACC; this is undoubtedly an imperfect process. Further analysis will be necessary as the capabilities of UTACC grow, and this list will need refinement and augmentation commensurate with the expanding role of UTACC in the operating forces. There will certainly be more tasks feasible as cameras and laser capabilities grow. This will cause the current list to change as well, making room for new MOPs and MOEs.

3. Machine Learning versus Human Experience

During LTA-2 it was noted that the UTACC system took approximately four hours to yield a complete rendering of the three-dimensional town, but the 80% solution took only about 10–15 minutes. Often in the military, it is more important to meet an imperfect threshold for information and then act decisively rather than waiting for perfect information and missing a critical opportunity to act; this is the pervasive paradox of military operations. If a planner determines that a unit can execute the mission at 80% or more of the MOP associated with M1 of UTACC 3.2, then the MOP mission accomplishment occurs in less than 15 minutes. However, if the planner decides that less than 100% is unacceptable, the unit will take sixteen times longer to execute. This example powerfully illustrates the importance of the threshold section of the MOP/MOE tables. Interestingly, once UTACC executed its first iteration, the follow on passes completed the same amount of rendering in even less time, due primarily to the information already stored from the previous run. This enhanced performance from stored data constitutes machine "experience" and is comparable to the development of experience within a human.

Extrapolating this concept will develop criteria for determining UTACC team proficiency, by determining how much "experience" the robotic elements have and equating it to the experience level of the human elements. This will be very useful in pre-deployment training and qualifications for combat. As artificial intelligence and machine learning advances, there will develop a natural disparity between the capabilities of the machine portion of UTACC and the human portion. If UTACC builds around the operating concept of a human/machine team, then it will inherit the same limitations of any other team; the members will only be as successful as the weakest link. One fascinating potential side effect of this conceptual exercise is that the relationship (and division of labor) between the human and machine members of UTACC be dynamic, in order to compensate and account for the inevitable task supremacy of the machine.

C. RECOMMENDATIONS FOR FURTHER RESEARCH

This thesis is the fourth in a series of efforts to propel forward the UTACC concept, and as such runs the risk of covering ground already addressed in previous work. There is no section where this applies more than recommendations for further research, as the teams that came before provided an exhaustive array of topics that can and should be explored to further the development of UTACC. If even fractions of the potential capabilities of UTACC come to life, it will affect every echelon of the United States military and militaries around the world. Thus, the impetus to generate and discuss exciting new possibilities should remain at the forefront of any discussion of UTACC.

1. Previous Recommendations

In the UTACC Concept of Operations thesis (Rice et al., 2015), the authors postulated that UTACC would eventually need to handle more complex missions, to include integration with naval forces and security cooperation around the world. Further, they felt that UTACC would need to have internal and network security developed in accordance with DOD information assurance certification and accreditation process (DIACAP). Such a powerful system would inevitably be the target for enemy cyber forces, and efforts aligned with DIACAP standards mitigate risks associated such an adversary. Other areas of concern for the UTACC CONOPS thesis included information management, such as how to handle the Common Operational Picture (COP) between and within a unit employing UTACC, training, maintenance and many other technical aspects of the system, such as the user interface system and power supply (Rice et al., 2015).

The most recently published thesis, UTACC Coactive Design, addressed an entirely different series of research and development possibilities, focused understandably on more of the coactive design aspect of developing UTACC (Zach, 2016). The recommendations included expanding the use of IA table content well beyond that of LTA-2, effectively designing with the future in mind while taking into account “multiple pathways through a given alternative.” This approach offers better insight into the interdependencies within UTACC, which in turn improves design efforts (Zach, 2016). Another major point made by Zach echoes the thoughts of Singer (2009) in emphasizing that the future role of robots on the battlefield will be to take the place of humans in jobs that are considered dull, dirty or dangerous, and thus any design or development ideas for future applications should operate with that criteria in mind. Further thoughts proffered by the UTACC Coactive Design thesis included suggestions for analysis on the optimal mix of Marines and machines within UTACC, data emissions protection, rotating authority amongst the machines, and even robotic ethical decision-making and mission selection (Zach, 2016).

2. Future Recommendations

The authors concluded that following their own observation of the LTA planning process and observation of emerging UTACC capabilities, they could easily augment the previous UTACC thesis contributions with additional recommendations.

a. MOP/MOE Tables for Six Warfighting Functions

UTACC began as an augmentation to Marine units engaged in an intelligence-gathering role, which necessitated the emphasis on MCT 2 focusing on reconnaissance. However, as the program capability expands UTACC teams should explore the other warfighting functions to determine the extent of potential UTACC incorporation into that function. For example, logistics remains at the heart of any operation, whether in combat or training, and the Marines in charge of planning and executing logistical operations are often times called upon to work incredibly long hours and perform herculean tasks to meet a mission deadline. If UTACC were able to aid in mission planning, route and supply chain optimization, anomaly detection on routes, loading and unloading of supplies, or even security operations it would greatly enhance the logistical operations of any unit into which the system is integrated. Similar benefits apply to aviation operations, command and control, communications and ground maneuver operations, which underlines the need for further research into integration of UTACC into the remaining warfighting functions.

b. Augmenting Baseline Mapping Resources/Assumptions:

Numerous open source mapping resources exist that could augment a UTACC system understanding of a local environment. The preeminent open source applications for geospatial intelligence in the modern era may very well be the collective knowledge available through Google Maps and Google Earth. These client interfaces provide any user with worldwide internet access the ability to download and analyze overhead satellite imagery and three-dimensional data depicting both natural terrain and urban buildings in most major cities around the world.

One of the fundamental assumptions of the recent UTACC demonstrations was the “blank slate” baseline seen in the LTA-2 scenarios, where the UTACC system began each mission with no data about the operating environment. This facilitated evaluation of the current UTACC configuration’s (available platforms and sensors) ability to develop a point-cloud map of the LTA-2 environment. However, in a more realistic future scenario, the UTACC system and small Marine unit would likely enter a mission with some rudimentary understanding of the lay of the land and possibly even three-dimensional mapping of the urban environment. This data could be available from the most recent human intelligence (HUMINT) or remote-sensing information gathered from the operating area. This initial understanding of the battlespace could not only shape the commander’s Operational Order (OpOrder), but in the case of UTACC it could also inform and refine the algorithms affecting UTACCs self-determined waypoint guidance and mapping of the objective area.

Future teams could accomplish significant research with regard to studying remote sensing platforms, HUMINT data and historical topographical data as they augment the UTACC point-cloud mapping algorithms/configuration. This merger of data sources could only inform and augment the UTACC decision-making process and operational functions, enhancing the ability to map the area and better inform the warfighter of the operating area.

c. Close Air Support Integration:

During LTA-2, the collaborative efforts of the MCWL and Naval Surface Warfare Center Carderock led to the evaluation of UTACC’s ability to generate and disseminate targeting information in a semi-autonomous manner. Specifically, during LTA-2 the organic UTACC platforms and sensors networked and interfaced with capabilities aboard a M80 Stiletto demonstration vessel. The M80, equipped with a notional surface-to-surface strike capability, was able to generate and populate a fire mission for a surface-to-surface strike package using data automatically propagated by the UTACC system.

The logical subsequent progression from a surface-to-surface fire mission is to incorporate the same UTACC functionality into generating air-to-surface fire missions as well as other fire mission solutions to auto-generated targeting data. There are a variety of digitally based fire mission applications in use today within the DOD, including software such as TACP-CAS, PISSOF, STRIKELINK, and many others (JP 3–09.3). The ability for UTACC to inform air-to-surface (ground or afloat) strike is an inevitable progression for the refinement of both the Marine Corps and Joint targeting cycle. Future research efforts along these lines must occur with the dedication of a resident expert in practices such as Joint Terminal Attack Control and Close Air Support.

D. SECTION CONCLUSION

The UTACC program is in its infancy, but the concept has such profound implications that it is not a question of if it should be pursued; the question is who will get there first? According to Singer (2009), robotic war technology is changing the very meaning of what it means to be a warrior, and what the actual experience of war will be for the soldier who fights on the battlefields of the future. Technology with the power to ignite a worldwide revolution in how humans engage in conflict with one another will inevitably, and has already, become a race to see who can develop the most capable machines first. The authors' recommendations for further research merely scratch the surface of what lies in store for the future of robotics and artificial intelligence across the world. Thus, it is with the greatest sense of duty and obligation to the safety of our nation that we recommend that this work continue, not just to extend American military dominance into the next century but also to protect and empower the men and women who make up its ranks.

According to Grossman and Christensen (2007), the range of responses to sensory overload during combat operations can affect everything from hearing to brain function to bowel control. He goes on to describe certain situations where a person who is experiencing cognitive overload in response to traumatic stress cannot remember simple details or even make use of the fine motor skills needed to punch 911 into a phone to call for help (Grossman & Christensen, 2007). More often than not, in that extreme cauldron of noise and violence, the young Marine is being asked not only to think clearly but to make life and death decisions that will affect everyone around him. If a fully functional

UTACC system can relieve operator cognitive overload, while at the same time removing the need for a human to even be in the line of fire, the issue of developing such a technology as quickly as possible is not just a smart military decision; it is a moral imperative for our nation.

APPENDIX A. BAMCIS MCT WITH SUGGESTED MOPS

This shows the master file of suggested UTACC metrics and example thresholds.

BAMCIS	Phase Description	MCT	MCT Description	MOP	Result	Units	MOP Description
Begin Planning	Initialize System/Set Preferences + Enter Mission Parameters	UTACC 1.1	Set the Desired Level of Autonomy	M1	H	L/M/H	Define the general nature of each H-M relationship and understand the role within each level
		UTACC 1.2	Enter Mission Parameters	M1	75	%	Input Orientation: Upload the present location, direction of attack and objective, and known key terrain data
		UTACC 1.2	Enter Mission Parameters	M2	80	%	Situation: Contains information on enemy (which will include SALUTE, DRAW-D, EMLCOA and EMDCOA) and friendly (which includes locations and missions of higher, adjacent and supporting units)
		UTACC 1.2	Enter Mission Parameters	M3	55	%	Mission: Upload the UxV's mission as related to the mission of the team (Who, What, When, Where, Why). Include tactical tasks.
		UTACC 1.2	Enter Mission Parameters	M4	60	%	Execution: Upload Concept of Operations (Commander's Intent, Scheme of Maneuver, Fire Support Plan), Tasks and Coordinating Instructions
		UTACC 1.2	Enter Mission Parameters	M5	67	%	Admin and Logistics: Define number and roles of humans and robots collaborating in team environment, and establish refueling and RTB points if different from origin
		UTACC 1.2	Enter Mission Parameters	M6	99	%	Command and Signal Plan: Upload Command, Signal, Retransmit and Comm Plans
Arrange/Make Recon	UAV maps (LIDAR) area + UGV maps (FR)/Select Emphasis Area	2.2.1.2	Conduct Area Reconnaissance	M1	0.2	Hrs	From receipt of tasking, unit reconnaissance assets in place.
		2.2.1.2	Conduct Area Reconnaissance	M2	Y	Y/N	Provide photographic and descriptive data of the Named Area of Interest to the Commander and staff.
		2.2.1.2	Conduct Area Reconnaissance	M4	5	Hrs	To conduct reconnaissance before movement of main body.
		2.2.1.3	Conduct Zone Reconnaissance	M1	0.5	Hrs	From receipt of tasking, unit reconnaissance assets in place.
		2.2.1.3	Conduct Zone Reconnaissance	M2	N	Y/N	Provide photographic and descriptive data of the Named Area of Interest (NAI) to the Commander and staff.
		2.2.1.3	Conduct Zone Reconnaissance	M12	2	Hrs	To conduct reconnaissance before movement of main body.
		2.2.5.2	Conduct Aviation Reconnaissance	M3	34	%	Of equipment ready and available to provide air reconnaissance operations.
		2.2.5.2	Conduct Aviation Reconnaissance	M4	Y	Y/N	Product (sensor) dissemination/distribution network available.
		2.2.5.2	Conduct Aviation Reconnaissance	M7	N	Y/N	Able to communicate relevant reconnaissance information using line-of-site (LOS)/beyond-line-of-site (BLOS) means.
		2.7	Conduct Ground Reconnaissance and Surveillance	M2	45	%	Of equipment ready and available to provide reconnaissance and surveillance operations (i.e., communications, target designation, crew served weapons, infiltration/exfiltration equipment, mobility assets).
		2.7	Conduct Ground Reconnaissance and Surveillance	M3	Y	Y/N	Capable of conducting ground reconnaissance and surveillance across the MAGTF Commander's area of influence.
		2.7	Conduct Ground Reconnaissance and Surveillance	M4	1	Hrs	From receipt of tasking, unit reconnaissance/surveillance assets in place.
		2.7	Conduct Ground Reconnaissance and Surveillance	M5	70	%	Of collection requirements fulfilled by reconnaissance/surveillance assets.
		UTACC 2.1	Conduct Initial Mapping - Depart Friendly Lines	M1	Y	Y/N	Resolve airspace deconfliction and meet safety threshhold for launch.
		UTACC 2.1	Conduct Initial Mapping - Geo Scan	M2	2	Hrs	Understand the size of area to scan between origin and objective. Scan the area between origin and objective for specific geographic features. Scan objective area for basic geography. Execute mapping protocol. Generate actionable information.
		UTACC 2.1	Conduct Initial Mapping - Build Map	M3	1.5	Hrs	Transmit map info, identify urban and wooded areas, identify masked areas, fill in gaps in intel.
		UTACC 2.1	Conduct Initial Mapping - Notify When Near Completion of Mapping	M4	Y	Y/N	Alert Marine when planning threshold is hit.
		UTACC 2.1	Conduct Initial Mapping - Monitor System Health	M5	70	%	Understand when to return for maintenance or refueling
		UTACC 2.2	Select Emphasis Area - Review Map	M1	0.5	Hrs	Different angle, higher resolution, different sensor, camera direction, multiple directions. Identify potential danger areas, routes, LZ's, water features…etc.
		UTACC 2.2	Select Emphasis Area - Query External/Joint Assets/COP	M2	1.5	Hrs	Assimilate all available information from adjacent and higher sources and incorporate relevant information into the digitized map data
	ID Possible Route (Marine) (FR)	2.2.1.1	Conduct Route Reconnaissance	M1	1	Hrs	From receipt of tasking, unit reconnaissance assets in place.
		2.2.1.1	Conduct Route Reconnaissance	M3	0.5	Hrs	To complete reconnaissance.
		2.2.1.1	Conduct Route Reconnaissance	M4	1	Hrs	To conduct initial route study (dismounted/mounted).
		2.2.1.2	Conduct Area Reconnaissance	M15	70	%	Of obstacles on movement routes identified before they can impede or halt movement of main body.
		2.2.1.2	Conduct Area Reconnaissance	M18	25	%	Of obstacles astride the route identified by reconnaissance prior to arrival of main body.
		2.2.3	Conduct Terrain Reconnaissance	M1	1	Hrs	From receipt of tasking, unit reconnaissance assets in place.
		2.2.3	Conduct Terrain Reconnaissance	M2	Y	Y/N	Provide photographic and descriptive data of the urban terrain to the Commander and staff.
		2.2.3	Conduct Terrain Reconnaissance	M4	2	Hrs	To conduct reconnaissance before movement of main body.
		UTACC 3.1	Conduct Detailed Mapping	M1	70	%	Scan Emphasis Areas. Execute detailed mapping protocol (the protocol will be different for why we selected the area for additional emphasis) ie. If for LZ, execute the LZ protocol, if for route then etc. Build detailed map collaboratively.
		UTACC 3.1	Conduct Detailed Mapping	M2	Y	Y/N	Alert Team to Relevant Info.Transmit map information relevant to mission
		UTACC 3.1	Conduct Detailed Mapping	M3	Y	Y/N	Notify When Near Completion. Alert Marine when planning threshold is hit.
		UTACC 3.1	Conduct Detailed Mapping	M4	25	%	Monitor System Health. Understand when to return for maintenance or refueling
		UTACC 3.2	MCOO	M1	25	%	Depict Vegetation. Depict type of vegetation, tree spacing, trunk diameter, soil types, and conditions that affect mobility.
		UTACC 3.2	MCOO	M2	25	%	Depict Surface Drainage. Depict water sources (width, depth, velocity, bank slope, height, and potential flood zones)
		UTACC 3.2	MCOO	M3	25	%	Depict All Other Effects. Depict surface configuration (elevation, slopes that affect mobility, line of sight for equipment usage. Depict obstacles, natural and manmade. Transportation systems (bridge classification and road characteristics such as curve radius, slopes, and width)
		UTACC 3.2	MCOO	M4	25	%	Depict Combined Obstacles. Depict terrain (severely restricted, restricted and unrestricted)
		UTACC 3.2	MCOO	M5	25	%	Depict Mobility Corridors and Avenues of Approach. Mobility corridors are that area within an AA that allows a particular sized unit to deploy and maneuver in its doctrinal, tactial formation. The corridors depicted by UTACC should correspond to the most common unit that will be deployed in the proposed mission sets. Avenues of Approach should encompass the Main Effort, Supporting Effort and the Air Avenue of Approach and should be depicted from estimated start point to proposed objective.
	Confirm Rte before UGV Deploy (FR)	2.2.1.1	Conduct Route Reconnaissance	M2	Y	Y/N	Route/road confirmed.
	Develop Alt Rte (FR)/UGV Use Map to Search For Targets	2.2.1.1	Conduct Route Reconnaissance	M5	1	Hrs	To identify bypass of obstacles that will impede, delay, or halt the movement of the main body.
		2.2.1.2	Conduct Area Reconnaissance	M3	1	Hrs	To identify bypass around obstacles blocking the concentration of tactical forces.
		2.2.1.2	Conduct Area Reconnaissance	M5	1	Hrs	To identify bypass of obstacles that will impede, delay, or halt the movement of the main body.
		2.2.1.2	Conduct Area Reconnaissance	M12	2	Hrs	To redirect reconnaissance assets to meet new collection requirement.
		2.2.1.2	Conduct Area Reconnaissance	M15	30	%	Of obstacles on movement routes identified before they can impede or halt movement of main body.
		2.2.1.2	Conduct Area Reconnaissance	M18	40	%	Of obstacles astride the route identified by reconnaissance prior to arrival of main body.
		2.2.3	Conduct Terrain Reconnaissance	M3	4	Hrs	To identify bypass around obstacles blocking the concentration of tactical forces.
		UTACC 4.1	UGV Correlates Visual Data with Map Data	M1	25	%	Using the map for correlation, UGV surveys the area and cross-references the images with stored data to locate pre-designated targets and High Value Individuals
		UTACC 4.2	UGV Monitors System Health	M1	25	%	UGV should monitor system to know when to return for maintenance or refueling/resupply of batteries
		UTACC 4.3	UGV Surveys Area for Threat Activity	M1	Y	Y/N	UGV will use visual data to identify indications and warnings of enemy or threat activity. This is a self-preservation function that will also serve as a force protection measure for human-machine integrated units.
		UTACC 4.4	UGV Successfully Navigates Around Obstacles	M1	Y	Y/N	UGV uses map data and visual sensors to determine if reconnaissance route has changed or if any new obstacles will impede accomplishment of its mission.
	If 2 unsuccessful, use UAV to search	UTACC 5.1	UAV Correlates Visual Data with Map Data	M1	75	%	Using the map for correlation, UAV surveys the area and cross-references the images with stored data to locate pre-designated targets and High Value Individuals
		UTACC 5.2	UAV Monitors System Health	M1	33	%	UAV should monitor system to know when to return for maintenance or refueling/resupply of batteries
		UTACC 5.3	UAV Surveys Area for Threat Activity	M1	Y	Y/N	UAV will use visual data to identify indications and warnings of enemy or threat activity. This is a self-preservation function that will also serve as a force protection measure for human-machine integrated units.
	Was search Successful?	2.2	Collect Data and Intelligence				
		2.2	Collect Data and Intelligence				
Complete Plan	Develop and Refine Mission Profiles + Submit to HHQ for Approval	UTACC 6.1	Develop Mission Profiles	M1	80	%	Develop Marine Only mission: Identify conditions that keep UxVs from partnering further (weather, security, timeliness), provide route from assembly area to objective, provide imagery of key terrain features along route and of objective area, and provide estimated timeline.
		UTACC 6.1	Develop Mission Profiles	M2	75	%	UAV Only
		UTACC 6.1	Develop Mission Profiles	M3	25	%	UGV Only
		UTACC 6.1	Develop Mission Profiles	M4	25	%	Marine and UAV
		UTACC 6.1	Develop Mission Profiles	M5	25	%	Marine and UGV
		UTACC 6.1	Develop Mission Profiles	M6	25	%	Marine, UAV and UGV
		UTACC 6.2	Refine Mission Profiles	M1	Y	Y/N	Select profile(s) needing refinement
		UTACC 6.2	Refine Mission Profiles	M2	Y	Y/N	Select areas needing refinement
		UTACC 6.2	Refine Mission Profiles	M3	Y	Y/N	Conduct refinement (selection of alternate route, require which agents utilize routes)
		UTACC 6.3	Select Mission Profiles	M1	Y	Y/N	Select Mission Profile most suited for the mission parameters given.
		UTACC 6.4	Submit to HHQ for Approval	M1	Y	Y/N	Submit complete and comprehensive data package to HHQ and standby for approval.

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APPENDIX B. AUTHOR LTA GRADE SHEETS

The following grade sheets contain the scenario-aligned suggest metrics that were presented to MCWL to evaluate UTACC during the LTA. The dynamic LTA planning process is evident in the scenario-numbering scheme (e.g., Scenario 4 spinning off to Scenario 4.5, and Scenario 6 skipping to Scenario 8), which reflect the changing understanding of UTACC's capabilities and the desire to evaluate the system in different environments with different tasks.

Scenario 1 – Jointly Produce Map								
MCT	MCT Description	MOP	Result	Unit	Grade L	M	H	Comments
UTACC 1.2	Enter Mission Parameters	M1		%				
UTACC 1.2	Enter Mission Parameters	M2		%				
UTACC 1.2	Enter Mission Parameters	M3		%				
UTACC 1.2	Enter Mission Parameters	M4		%				
UTACC 1.2	Enter Mission Parameters	M5		%				
2.2.1.2	Conduct Area Reconnaissance	M1		Hrs				
2.2.1.2	Conduct Area Reconnaissance	M2		Y/N				
2.2.1.3	Conduct Zone Reconnaissance	M1		Hrs				
2.2.1.3	Conduct Zone Reconnaissance	M2		Y/N				
2.2.5.2	Conduct Aviation Reconnaissance	M3		%				
2.2.5.2	Conduct Aviation Reconnaissance	M4		Y/N				
2.2.5.2	Conduct Aviation Reconnaissance	M7		Y/N				

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2.7	Conduct Ground Reconnaissance and Surveillance	M2		%					
2.7	Conduct Ground Reconnaissance and Surveillance	M4		Hrs					
2.7	Conduct Ground Reconnaissance and Surveillance	M5		%					
UTACC 2.1	Conduct Initial Mapping - Depart Friendly Lines	M1		Y/N					
UTACC 2.1	Conduct Initial Mapping - Geo Scan	M2		Hrs					
UTACC 2.1	Conduct Initial Mapping - Build Map	M3		Hrs					
UTACC 2.2	Select Emphasis Area - Review Map	M1		Hrs					
2.2.1.1	Conduct Route Reconnaissance	M4		Hrs					
UTACC 3.1	Conduct Detailed Mapping	M1		%					
UTACC 3.2	MCOO	M2		%					
2.2.1.1	Conduct Route Reconnaissance	M2		Y/N					

APPENDIX B. AUTHOR LTA GRADE SHEETS

Scenario 2 - Target Only Visible to UGV								
MCT	MCT Description	MOP	Result	Unit	Grade L	M	H	Comments
2.2.1.2	Conduct Area Reconnaissance	M1		Hrs				
2.2.1.2	Conduct Area Reconnaissance	M2		Y/N				
2.2.1.3	Conduct Zone Reconnaissance	M1		Hrs				
2.2.1.3	Conduct Zone Reconnaissance	M2		Y/N				
2.2.5.2	Conduct Aviation Reconnaissance	M3		%				
2.2.5.2	Conduct Aviation Reconnaissance	M4		Y/N				
2.2.5.2	Conduct Aviation Reconnaissance	M7		Y/N				
2.7	Conduct Ground Reconnaissance and Surveillance	M2		%				
2.7	Conduct Ground Reconnaissance and Surveillance	M4		Hrs				
2.7	Conduct Ground Reconnaissance and Surveillance	M5		%				
2.2	Collect Data and Intelligence	M1		%				
2.2	Collect Data and Intelligence	M2		%				

APPENDIX B. AUTHOR LTA GRADE SHEETS

Scenario 3 - Target Only Visible to UAV								
MCT	MCT Description	MOP	Result	Unit	Grade L	M	H	Comments
2.2.1.2	Conduct Area Reconnaissance	M1		Hrs				
2.2.1.2	Conduct Area Reconnaissance	M2		Y/N				
2.2.1.3	Conduct Zone Reconnaissance	M1		Hrs				
2.2.1.3	Conduct Zone Reconnaissance	M2		Y/N				
2.2.5.2	Conduct Aviation Reconnaissance	M3		%				
2.2.5.2	Conduct Aviation Reconnaissance	M4		Y/N				
2.2.5.2	Conduct Aviation Reconnaissance	M7		Y/N				
2.7	Conduct Ground Reconnaissance and Surveillance	M2		%				
2.7	Conduct Ground Reconnaissance and Surveillance	M4		Hrs				
2.7	Conduct Ground Reconnaissance and Surveillance	M5		%				
2.2	Collect Data and Intelligence	M1		%				
2.2	Collect Data and Intelligence	M2		%				

APPENDIX B. AUTHOR LTA GRADE SHEETS

Scenario 4 - Target Not Present								
MCT	MCT Description	MOP	Result	Unit	Grade L	M	H	Comments
2.2.1.2	Conduct Area Reconnaissance	M1		Hrs				
2.2.1.2	Conduct Area Reconnaissance	M2		Y/N				
2.2.1.3	Conduct Zone Reconnaissance	M1		Hrs				
2.2.1.3	Conduct Zone Reconnaissance	M2		Y/N				
2.2.5.2	Conduct Aviation Reconnaissance	M3		%				
2.2.5.2	Conduct Aviation Reconnaissance	M4		Y/N				
2.2.5.2	Conduct Aviation Reconnaissance	M7		Y/N				
2.7	Conduct Ground Reconnaissance and Surveillance	M2		%				
2.7	Conduct Ground Reconnaissance and Surveillance	M4		Hrs				
2.7	Conduct Ground Reconnaissance and Surveillance	M5		%				
2.2	Collect Data and Intelligence	M1		%				
2.2	Collect Data and Intelligence	M2		%				

APPENDIX B. AUTHOR LTA GRADE SHEETS

Scenario 4.5 – Evasive Target								
MCT	MCT Description	MOP	Result	Unit	Grade L	M	H	Comments
2.2.1.2	Conduct Area Reconnaissance	M1		Hrs				
2.2.1.2	Conduct Area Reconnaissance	M2		Y/N				
2.2.1.3	Conduct Zone Reconnaissance	M1		Hrs				
2.2.1.3	Conduct Zone Reconnaissance	M2		Y/N				
2.2.5.2	Conduct Aviation Reconnaissance	M3		%				
2.2.5.2	Conduct Aviation Reconnaissance	M4		Y/N				
2.2.5.2	Conduct Aviation Reconnaissance	M7		Y/N				
2.7	Conduct Ground Reconnaissance and Surveillance	M2		%				
2.7	Conduct Ground Reconnaissance and Surveillance	M4		Hrs				
2.7	Conduct Ground Reconnaissance and Surveillance	M5		%				
2.2	Collect Data and Intelligence	M1		%				
2.2	Collect Data and Intelligence	M2		%				

APPENDIX B. AUTHOR LTA GRADE SHEETS

Scenario 5 - Only Incorrect Target(s) Present								
MCT	MCT Description	MOP	Result	Unit	Grade L	M	H	Comments
2.2.1.2	Conduct Area Reconnaissance	M1		Hrs				
2.2.1.2	Conduct Area Reconnaissance	M2		Y/N				
2.2.1.3	Conduct Zone Reconnaissance	M1		Hrs				
2.2.1.3	Conduct Zone Reconnaissance	M2		Y/N				
2.2.5.2	Conduct Aviation Reconnaissance	M3		%				
2.2.5.2	Conduct Aviation Reconnaissance	M4		Y/N				
2.2.5.2	Conduct Aviation Reconnaissance	M7		Y/N				
2.7	Conduct Ground Reconnaissance and Surveillance	M2		%				
2.7	Conduct Ground Reconnaissance and Surveillance	M4		Hrs				
2.7	Conduct Ground Reconnaissance and Surveillance	M5		%				
2.2	Collect Data and Intelligence	M1		%				
2.2	Collect Data and Intelligence	M2		%				

APPENDIX B. AUTHOR LTA GRADE SHEETS

Scenario 6 - Both Correct and Incorrect Targets Present								
MCT	MCT Description	MOP	Result	Unit	Grade L	M	H	Comments
2.2.1.2	Conduct Area Reconnaissance	M1		Hrs				
2.2.1.2	Conduct Area Reconnaissance	M2		Y/N				
2.2.1.3	Conduct Zone Reconnaissance	M1		Hrs				
2.2.1.3	Conduct Zone Reconnaissance	M2		Y/N				
2.2.5.2	Conduct Aviation Reconnaissance	M3		%				
2.2.5.2	Conduct Aviation Reconnaissance	M4		Y/N				
2.2.5.2	Conduct Aviation Reconnaissance	M7		Y/N				
2.7	Conduct Ground Reconnaissance and Surveillance	M2		%				
2.7	Conduct Ground Reconnaissance and Surveillance	M4		Hrs				
2.7	Conduct Ground Reconnaissance and Surveillance	M5		%				
2.2	Collect Data and Intelligence	M1		%				
2.2	Collect Data and Intelligence	M2		%				

APPENDIX B. AUTHOR LTA GRADE SHEETS

Scenario 8 – Start Hunt for Target at Suspected Location								
MCT	MCT Description	MOP	Result	Unit	Grade L	M	H	Comments
2.2.1.2	Conduct Area Reconnaissance	M1		Hrs				
2.2.1.2	Conduct Area Reconnaissance	M2		Y/N				
2.2.1.3	Conduct Zone Reconnaissance	M1		Hrs				
2.2.1.3	Conduct Zone Reconnaissance	M2		Y/N				
2.2.5.2	Conduct Aviation Reconnaissance	M3		%				
2.2.5.2	Conduct Aviation Reconnaissance	M4		Y/N				
2.2.5.2	Conduct Aviation Reconnaissance	M7		Y/N				
2.7	Conduct Ground Reconnaissance and Surveillance	M2		%				
2.7	Conduct Ground Reconnaissance and Surveillance	M4		Hrs				
2.7	Conduct Ground Reconnaissance and Surveillance	M5		%				
2.2	Collect Data and Intelligence	M1		%				
2.2	Collect Data and Intelligence	M2		%				

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APPENDIX C. MCWL LTA TABLES

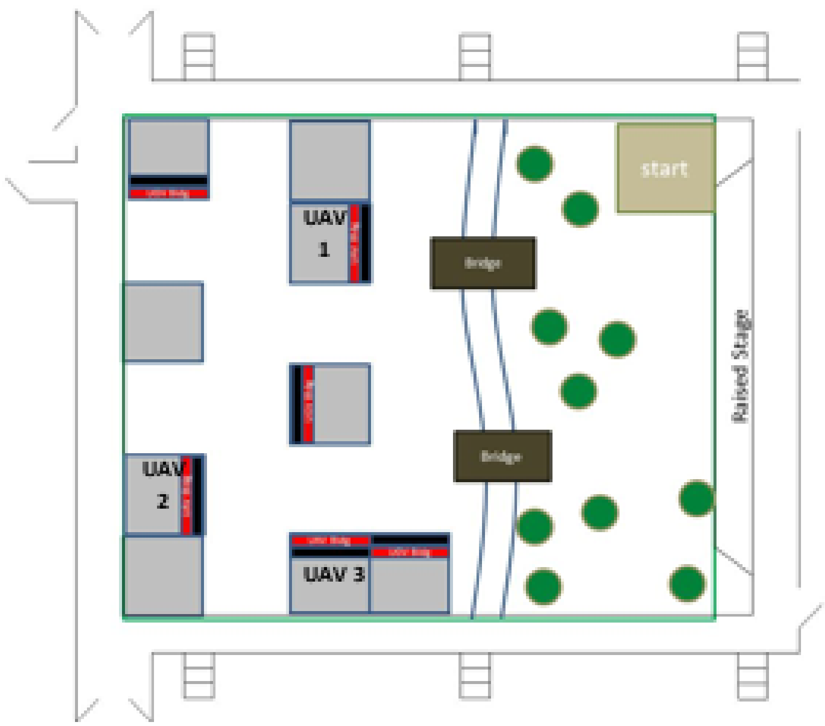
Appendix C material shows the MCWLs final LTA observer-grading product; an amalgamation of technical metrics, mission metrics, and note space for documenting the UTACC systems movements in the physical environment at the LTA.

Scenario: 1 Run # (circle): 1 2 3 4 5 Observer:____________________ Date:__________

Mission Type: Map/Reconnaissance

Scenario 1 - Jointly Produce Map

The system will be tasked to produce a map of the AoI. The system will start with a blank slate between each run.



Start Time:____________ Stop Time:____________ Result(Success or Failure):____________________

Task #	Time Issued	Command/Event	S	F	Notes/Observations (Issues, Clarifications, or Other Observations)
1.		Ability to add a prior map data for view and use in UI. Note 1.1: this functionality is not yet present but is expected in a future release.			

APPENDIX C. MCWL LTA TABLES

Scenario: 1 Run # (circle): 1 2 3 4 5 Observer:________________ Date:________

Mission Type: Map/Reconnaissance

Task #	Time Issued	Command/Event	S	F	Notes/Observations [Issues, Clarifications, or Other Observations]
2.		Ability to manipulate map (Zoom in/out, Pan left/right, North Up/Vehicle Up) for view and use in UI. Note 1.2: this functionality is not yet present but is expected in a future release.			
3.		Ability to geo-rectify (set scale, tie to GPS point or points, and provide north) map data for view and use in UI.Note 1.3: this functionality is not yet present but is expected in a future release.			
4.		Operator able to designate entire area as AOI in overview map imported in step 1			
5.		Operator ability to designate sub-area(s) as AOI(s) Note 1.4: this functionality is not yet present but is expected in a future release.			
6.		Ability to select Map mission in UI			
7.		Ability to execute Map mission			
8.		UGV produces map within AOI			
9.		UGV Stays within AOI			
10.		UGV accurately recognizes if it cannot complete mission, and alerts operator			

APPENDIX C. MCWL LTA TABLES

Scenario: 1   Run # (circle): 1 2 3 4 5   Observer: ______________________   Date: __________

Mission Type: Map/Reconnaissance

Task #	Time Issued	Command/Event	S	F	Notes/Observations [Issues, Clarifications, or Other Observations]
11.		UGV alerts Operator in UI to launch UAV to assist in map mission if it identifies an area not visible to the UGV.			
12.		Operator is able to accept or deny request to launch UAV. *Note 1.5: Currently the system does not offer the ability to "Deny" and therefore dismiss the prompt. Instead the option to launch stays enabled continuously for the rest of the mission.*			Operator selected to: Approves or Deny
13.		UGV continues mapping alone if prompt for UAV is ignored.			
14.		UAV Launches when request accepted			UAV Launch Time: __________
15.		UAV only maps regions not visible to UGV			UAV Buildings Mapped # (circle): 1 2 3
16.		System appears to fuse UGV & UAV maps correctly			Visual Inspection
17.		System appears to produce complete map of AOI			Visual Inspection

APPENDIX C. MCWL LTA TABLES

Scenario: 1 Run # (circle): 1 2 3 4 5 Observer:________________ Date:________

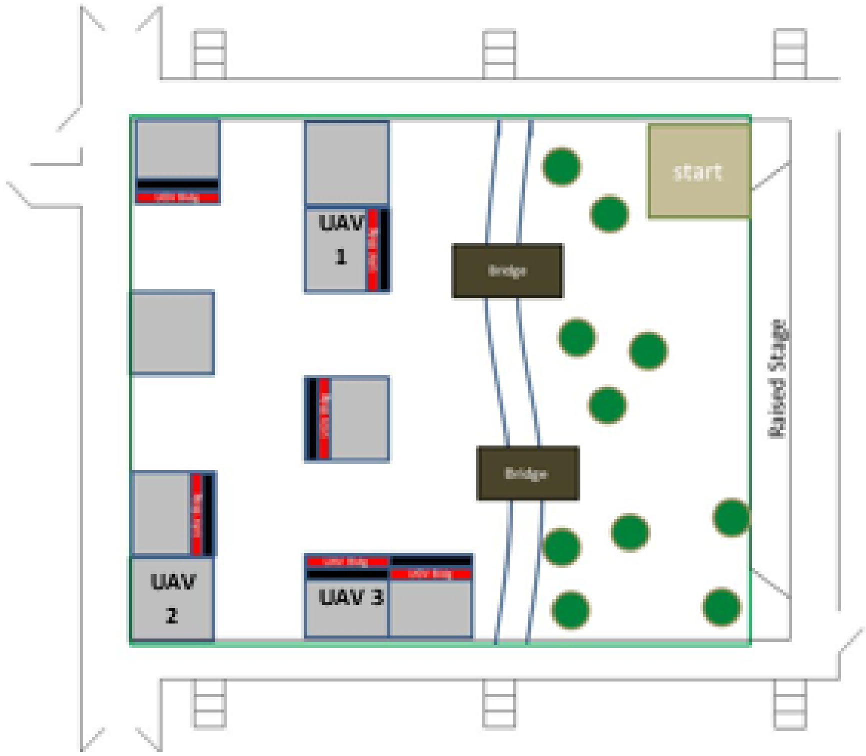
Mission Type: Map/Reconnaissance

Task #	Time Issued	Command/Event	S	F	Notes/Observations [Issues, Clarifications, or Other Observations]
18.		UI queries Operator to RTB or move to a designated RP for retrieval Note 1.6: this functionality is not yet present but is expected in a future release. Currently the system will halt in place upon map completion.			
19.		If RTB is selected, the UAV returns to and lands on the UGV, the UGV then returns to the starting point Note 1.7: see note 1.6.			
20.		If Operator selects "move to RP", the UI allows the operator to designate the location either via Creating a point on the map, or inputting coordinates Note 1.8: see note 1.6.			
21.		If Operator selected "move to RP", the UxVs move to defined RP Note 1.8: see note 1.6.			
22.		Systems complete the mission without incident.			
23.		UAV Autonomously lands when mission complete			UAV Land Time:________
24.		UAV Lands when out of battery power			UAV Land Time:________

APPENDIX C. MCWL LTA TABLES

Scenario: 1 Run # (circle): 1 2 3 4 5 Observer:____________________ Date:__________

Mission Type: Map/Reconnaissance



Notations	Notes/Observations (Issues, Clarifications, or Other Observations)
1.	
2.	
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8.	

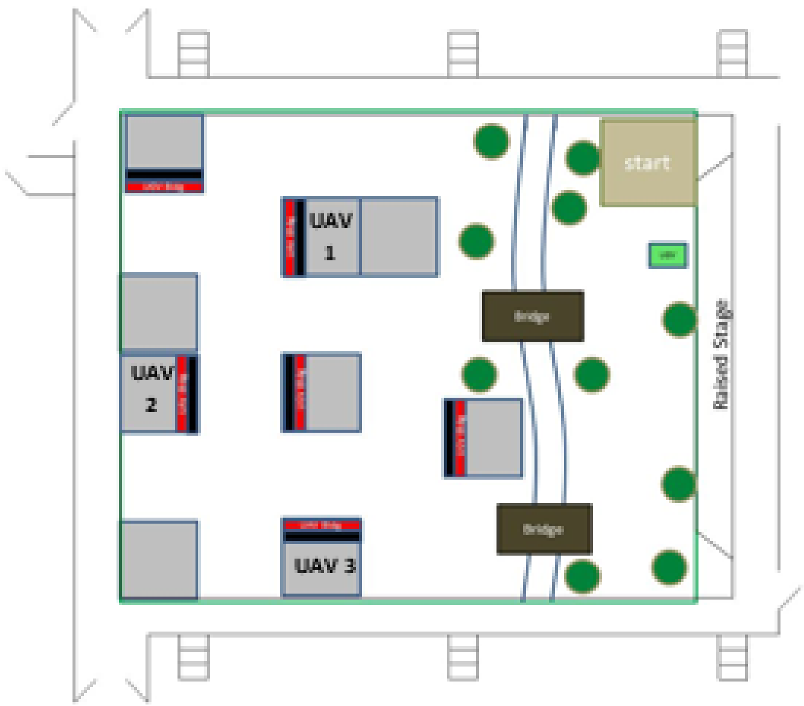
APPENDIX C. MCWL LTA TABLES

Scenario: 1.5 Run # (circle): 1 2 3 4 5 Observer:__________________ Date:________

Mission Type: Map/Reconnaissance

Scenario 1.5 - Jointly Produce Map

The system will be tasked to produce a map of the AoI. The system will start with a blank slate between each run.



Start Time:____________ Stop Time:____________ Result(Success or Failure):________________

Task #	Time Issued	Command/Event	S	F	Notes/Observations [Issues, Clarifications, or Other Observations]
1.		Ability to add a prior map data for view and use in UI. Note 1.5.1: this functionality is not yet present but is expected in a future release.			

APPENDIX C. MCWL LTA TABLES

Scenario: 1.5 Run # (circle): 1 2 3 4 5 Observer:__________ Date:__________

Mission Type: Map/Reconnaissance

Task #	Time Issued	Command/Event	S	F	Notes/Observations [Issues, Clarifications, or Other Observations]
2.		Ability to manipulate map (Zoom in/out, Pan left/right, North Up/Vehicle Up) for view and use in UI. Note 1.5.2: this functionality is not yet present but is expected in a future release.			
3.		Ability set image scale, tie to GPS point or points, and provide north for view and use in UI. Note 1.3: this functionality is not yet present but is expected in a future release.			
4.		Operator able to designate entire area as AOI in overview map imported in step 1			
5.		Operator ability to designate sub-area(s) as AOI(s) Note 1.5.4: this functionality is not yet present but is expected in a future release.			
6.		Ability to select Map mission in UI			
7.		Ability to execute Map mission			
8.		UGV produces map within AOI			
9.		UGV Stays within AOI			
10.		UGV accurately recognizes if it cannot complete mission, and alerts operator			

APPENDIX C. MCWL LTA TABLES

Scenario: 1.5 Run # (circle): 1 2 3 4 5 Observer:__________________________ Date:__________

Mission Type: Map/Reconnaissance

Task #	Time Issued	Command/Event	S	F	Notes/Observations [Issues, Clarifications, or Other Observations]
11.		UGV alerts Operator in UI to launch UAV to assist in map mission if it identifies an area not visible to the UGV.			
12.		Operator is able to accept or deny request to launch UAV. *Note 1.5.5: Currently the system does not offer the ability to "Deny" and therefore dismiss the prompt. Instead the option to launch stays enabled continuously for the rest of the mission.*			Operator selected to: Approves or Deny
13.		UGV continues mapping alone if prompt for UAV is ignored.			
14.		UAV Launches when request accepted			UAV Launch Time:__________
15.		UAV only maps regions not visible to UGV			UAV Buildings Mapped # (circle): 1 2 3
16.		System appears to fuse UGV & UAV maps correctly			Visual Inspection
17.		System appears to produce complete map of AOI			Visual Inspection

APPENDIX C. MCWL LTA TABLES

Scenario: 1.5 Run # (circle): 1 2 3 4 5 Observer:____________________ Date:__________

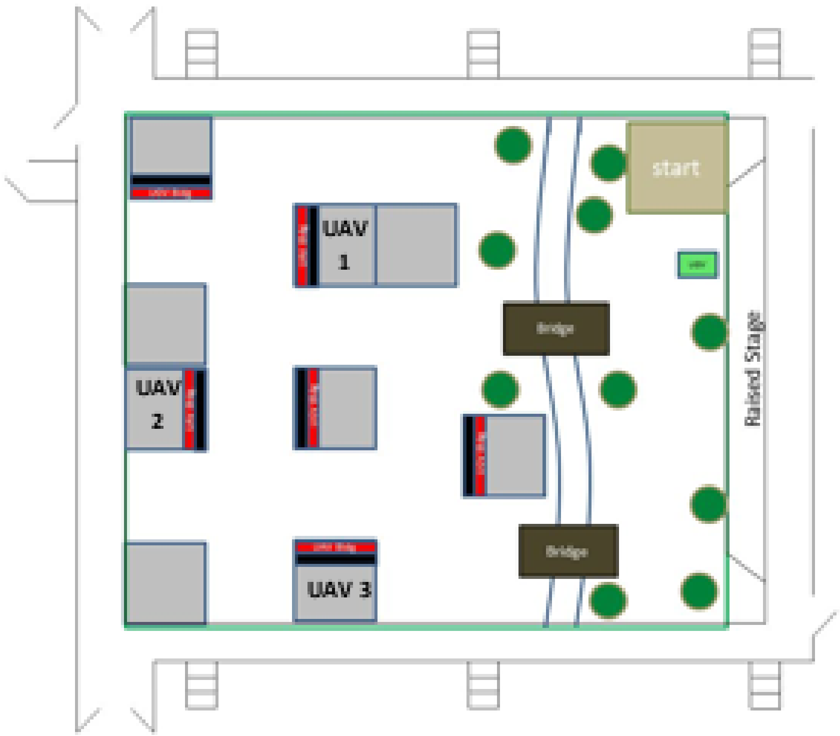
Mission Type: Map/Reconnaissance

Task #	Time Issued	Command/Event	S	F	Notes/Observations (Issues, Clarifications, or Other Observations)
18.		UI queries Operator to RTB or move to a designated RP for retrieval Note 1.5.6: this functionality is not yet present but is expected in a future release. Currently the system will halt in place upon map completion.			
19.		If RTB is selected, the UAV returns to and lands on the UGV, the UGV then returns to the starting point Note 1.5.7: see note 1.5.6.			
20.		If Operator selects "move to RP", the UI allows the operator to designate the location either via Creating a point on the map, or inputting coordinates Note 1.5.8: see note 1.5.6.			
21.		If Operator selected "move to RP", the UxVs move to defined RP Note 1.8: see note 1.5.6.			
22.		Systems complete the mission without incident.			
23.		UAV Autonomously lands when mission complete			UAV Land Time:__________
24.		UAV Lands when out of battery power			UAV Land Time:__________

APPENDIX C. MCWL LTA TABLES

Scenario: 1.5 Run # (circle): 1 2 3 4 5 Observer:__________________________ Date:__________

Mission Type: Map/Reconnaissance



Notations	Notes/Observations (Issues, Clarifications, or Other Observations)
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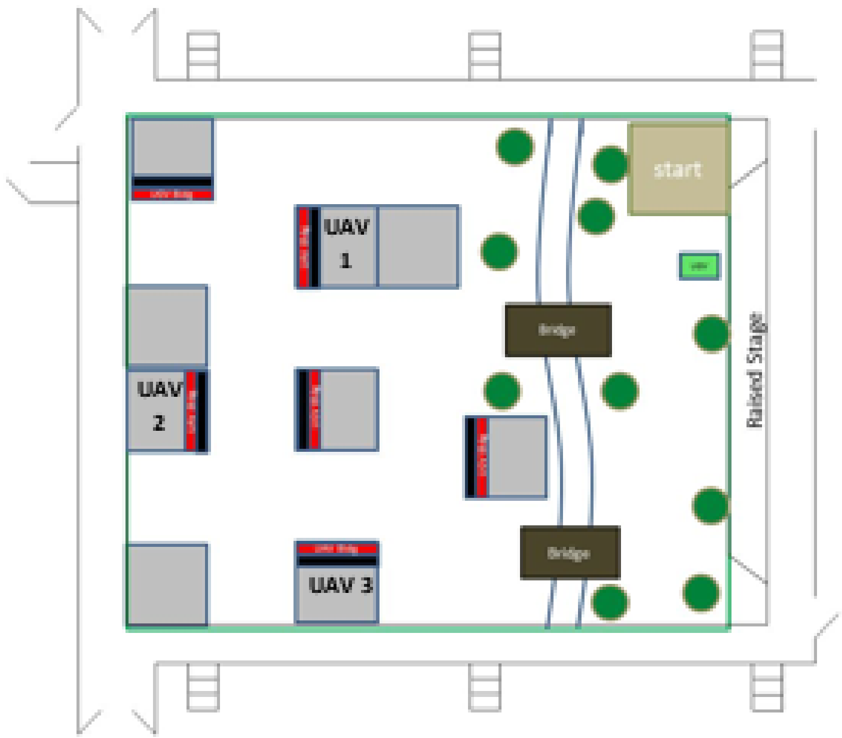
APPENDIX C. MCWL LTA TABLES

Scenario: 2 Run # (circle): 1 2 3 4 5 Observer:____________________ Date:________

Mission Type: Target Acquisition

Scenario 2 - Target Only Visible to UGV

The system will conduct this mission while reusing the map built in Scenario 1.5 "Jointly Produce Map of Alternate Environment", which will be loaded fresh between each run. The system will be trained to recognize the face of the PoI. The PoI will then be located where he/she will be visible to the UGV, but not the UAV – this will be accomplished using the "UGV view Bldg" as described in the test plan's "Typical Assessment Configurations". The "UGV view Bldg" will be located sufficiently far enough from the starting point such that the UAV will also have been deployed. The system will be tasked to search for, recognize, and report the location of the PoI.



Start Time:______________ **Stop Time:**______________ Result(Success or Failure):________________

APPENDIX C. MCWL LTA TABLES

Scenario: 2 Run # (circle): 1 2 3 4 5 Observer:________________________ Date:__________

Mission Type: Target Acquisition

Task #	Time Issued	Command/Event	S	F	Notes/Observations [Issues, Clarifications, or Other Observations]
1.		Operator able to designate entire area as AOI in overview map imported in step 1			
2.		Operator able to designate sub-area(s) as AOI(s) Note 2.4: this functionality is not yet present but is expected in a future release.			
3.		User able to add OOIs & POIs			# POI Added: ____ # OOI Added: ____
4.		Ability to select Find mission in UI			
5.		Ability to execute Find mission			
6.		UGV produces map within AOI			
7.		UGV Stays within AOI			
8.		UGV accurately recognizes if it cannot complete mission, and alerts operator			
9.		UGV alerts Operator in UI to launch UAV to assist in map mission if it identifies an area not visible to the UGV			
10.		Operator is able to accept or deny request to launch UAV			Operator selected to: Approves or Deny
11.		UGV continues mapping alone if prompt for UAV is denied.			

APPENDIX C. MCWL LTA TABLES

Scenario: 2 Run # (circle): 1 2 3 4 5 Observer:____________ Date:______

Mission Type: Target Acquisition

Task #	Time Issued	Command/Event	S	F	Notes/Observations [Issues, Clarifications, or Other Observations]
12.		UAV Launches when request accepted			UAV Launch Time:______
13.		UAV only maps regions not visible to UGV			UAV Buildings Mapped # (circle): 1 2 3
14.		System appears to fuse UGV & UAV maps correctly			Visual Inspection
15.		System appears to produce complete map of AOI			Visual Inspection
16.		POI(s) successfully detected by UGV			# POI Dectected:___
17.		OOI(s) successfully detected by UGV			# OOI Detected:___
18.		User Prompted to confirm/deny			
19.		Ability to confirm POI/OOI detection			
20.		Ability to Deny detection			
21.		Successful response action to Accept/Deny			
22.		Target coordinates are successfully sent to LOC/Stiletto Note: Not a UTACC test.			
23.		UI displays message from LOC/Stiletto "Request Engagement?" and allows user to select "yes" or "no". Note: Not a UTACC test.			

APPENDIX C. MCWL LTA TABLES

Scenario: 2 Run # (circle): 1 2 3 4 5 Observer:______________ Date:__________

Mission Type: Target Acquisition

Task #	Time Issued	Command/Event	S	F	Notes/Observations [Issues, Clarifications, or Other Observations]
24.		If yes is selected, notifies LOC/Stiletto to launch missile. Note: Not a UTACC test.			
25.		UI displays message from LOC/Stiletto "Missile Launched". Note: Not a UTACC test.			
26.		UI displays query from LOC/Stiletto "Provide Battle Damage Assessment", with selectable options of "target missed", "target damaged", and "target destroyed". Note: Not a UTACC test.			
27.		Sends LOC/Stiletto appropriate Battle damage Assessment. Note: Not a UTACC test.			
28.		UI queries Operator to RTB, move to a designated RP for retrieval, or continue searching for additional targets Note 2.5: this functionality is not yet present but is expected in a future release. Currently the system will halt in place upon map completion.			
29.		If RTB is selected, the UAV returns to and lands on the UGV, the UGV then returns to the starting point Note 2.6: see note 2.5. Also, UAV will not land on UGV.			
30.		If Operator selects "move to RP", the UI allows the operator to designate the location either via touch a point on the map, or inputting coordinates Note 2.7: see note 2.5.			

APPENDIX C. MCWL LTA TABLES

Scenario: 2 Run # (circle): 1 2 3 4 5 Observer:_________________________ Date:__________

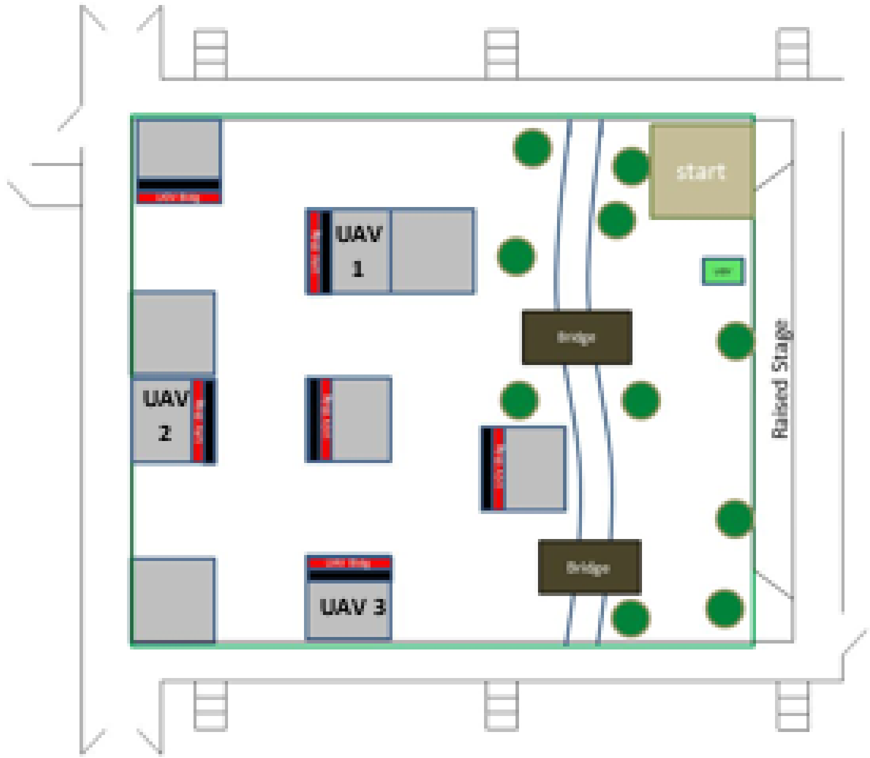
Mission Type: Target Acquisition

Task #	Time Issued	Command/Event	S	F	Notes/Observations [Issues, Clarifications, or Other Observations]
31.		If Operator selected "move to RP", the UxVs move to defined RP Note 2.8: see note 2.5.			
32.		If Operator selected "continue searching for additional targets", the UxVs continue searching for other targets if specified. Note 2.9: see note 2.5.			
33.		Accepts an interrupt command to RTB or move to RP despite an earlier instruction to continue searching; Note 2.10: see note 2.5.			
34.		Systems complete the mission without incident.			
35.		UAV Autonomously lands when mission complete			UAV Land Time:____________
36.		UAV Lands when out of battery power			UAV Land Time:____________
37.		If Operator selects "move to RP", the UI allows the operator to designate the location either via touch a point on the map, or inputting coordinates Note 2.7: see note 2.5.			
38.		If Operator selected "move to RP", the UxVs move to defined RP Note 2.8: see note 2.5.			
39.		Systems complete the mission without incident.			
40.		UAV Autonomously lands when mission complete			UAV Land Time:____________
41.		UAV Lands when out of battery power			UAV Land Time:____________

APPENDIX C. MCWL LTA TABLES

Scenario: 2 Run # (circle): 1 2 3 4 5 Observer: ______________________ Date: ________

Mission Type: Target Acquisition



Notations	Notes/Observations [Issues, Clarifications, or Other Observations]
1.	
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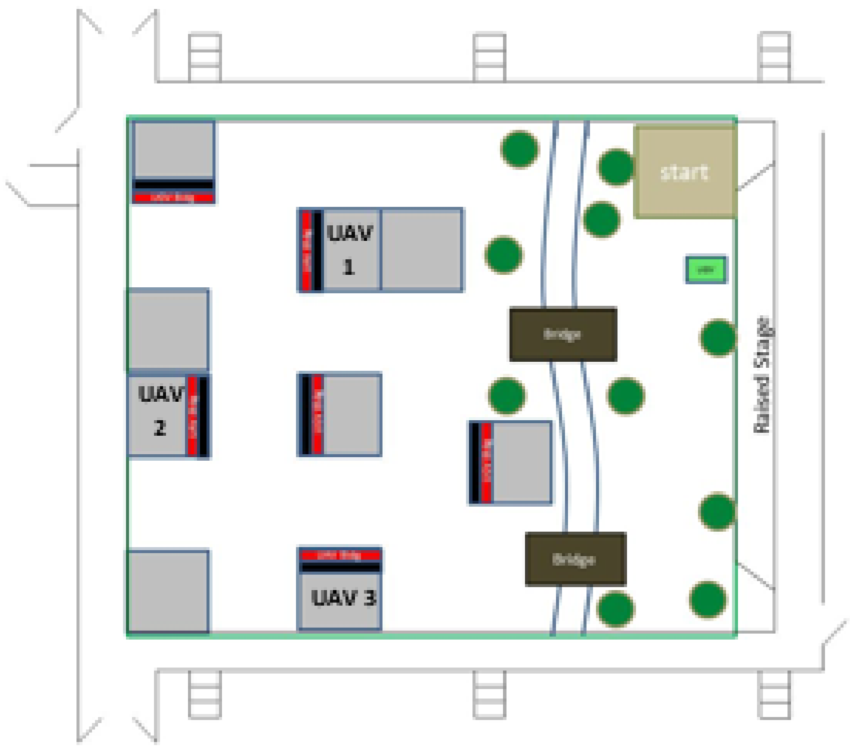
APPENDIX C. MCWL LTA TABLES

Scenario: 3 Run # (circle): 1 2 3 4 5 Observer:____________________ Date:________

Mission Type: Target Acquisition

Scenario 3 - *Target Only Visible to UAV*

The system will conduct this mission while reusing the map built in Scenario 1.5, which will be loaded fresh between each run. The system will be trained to recognize the face of the PoI. The PoI will then be located where he/she will be visible to the UAV, but not the UGV – this will be accomplished using the "UAV view Bldg" as described in the test plan's "Typical Assessment Configurations". The system will be tasked to search for, recognize, and report the location of the PoI.



Start Time:________________ **Stop Time:**________________ Result(Success or Failure):________________

APPENDIX C. MCWL LTA TABLES

Scenario: 3 Run # (circle): 1 2 3 4 5 Observer:____________ Date:________

Mission Type: Target Acquisition

Task #	Time Issued	Command/Event	S	F	Notes/Observations [Issues, Clarifications, or Other Observations]
1.		Operator able to designate entire area as AOI in overview map.			
2.		Operator able to designate sub-area(s) as AOI(s) Note 2.4: this functionality is not yet present but is expected in a future release.			
3.		User able to add OOIs & POIs			# POI Added:____ # OOI Added:____
4.		Ability to select Find mission in UI			
5.		Ability to execute Find mission			
6.		UGV produces map within AOI			
7.		UGV Stays within AOI			
8.		UGV accurately recognizes if it cannot complete mission, and alerts operator			
9.		UGV alerts Operator in UI to launch UAV to assist for search mission if it identifies an area not visible to the UGV			
10.		Operator is able to accept or deny request to launch UAV			Operator selected to: Approves or Deny
11.		UGV continues searching alone if prompt for UAV is denied.			

APPENDIX C. MCWL LTA TABLES

Scenario: 3 Run # (circle): 1 2 3 4 5 Observer:______________ Date:________

Mission Type: Target Acquisition

Task #	Time Issued	Command/Event	S	F	Notes/Observations (Issues, Clarifications, or Other Observations)
12.		UAV Launches when request accepted			UAV Launch Time:________
13.		UAV only searches regions not visible to UGV			UAV Buildings Mapped # (circle): 1 2 3
14.		System appears to fuse UGV & UAV maps correctly			Visual Inspection
15.		POI(s) successfully detected by UGV			# POI Dectected:____
16.		OOI(s) successfully detected by UGV			# OOI Detected:____
17.		User Prompted to confirm/deny			
18.		Ability to confirm POI/OOI detection			
19.		Ability to Deny detection			
20.		Successful response action to Accept/Deny			
21.		Target coordinates are successfully sent to LOC/Stilleto Note: Not a UTACC test.			
22.		UI displays message from LOC/Stiletto "Request Engagement?" and allows user to select "yes" or "no". Note: Not a UTACC test.			
23.		UI displays message from LOC/Stiletto "Missile Launched". Note: Not a UTACC test.			

APPENDIX C. MCWL LTA TABLES

Scenario: 3 Run # (circle): 1 2 3 4 5 Observer:__________________________ Date:__________

Mission Type: Target Acquisition

Task #	Time Issued	Command/Event	S	F	Notes/Observations [Issues, Clarifications, or Other Observations]
24.		UI displays query from LOC/Stiletto "Provide Battle Damage Assessment", with selectable options of "target missed", "target damaged", and "target destroyed". Note: Not a UTACC test.			
25.		Sends LOC/Stiletto appropriate Battle damage Assessment. Note: Not a UTACC test.			
26.		UI queries Operator to RTB, move to a designated RP for retrieval, or continue searching for additional targets Note 2.5: this functionality is not yet present but is expected in a future release. Currently the system will halt in place upon map completion.			
27.		If RTB is selected, the UAV returns to and lands on the UGV, the UGV then returns to the starting point Note 2.6: see note 2.5. Also, UAV will not land on UGV.			
28.		If Operator selects "move to RP", the UI allows the operator to designate the location either via touch a point on the map, or inputting coordinates Note 2.7: see note 2.5.			
29.		If Operator selected "move to RP", the UxVs move to defined RP Note 2.8: see note 2.5.			

APPENDIX C. MCWL LTA TABLES

Scenario: 3 Run # (circle): 1 2 3 4 5 Observer:____________________ Date:__________

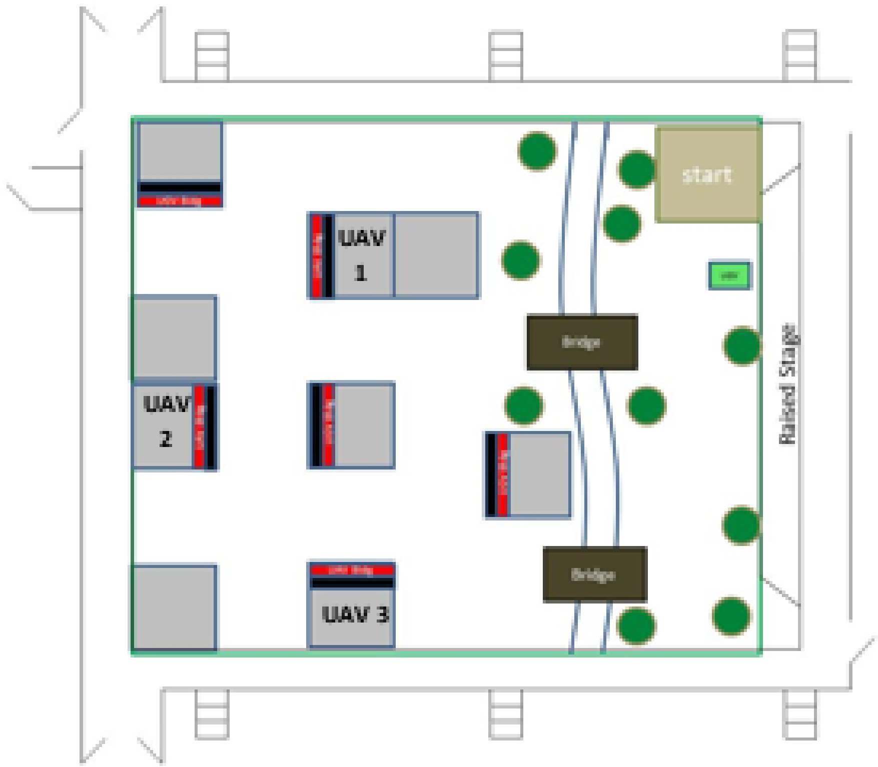
Mission Type: Target Acquisition

Task #	Time Issued	Command/Event	S	F	Notes/Observations [Issues, Clarifications, or Other Observations]
30.		If Operator selected "continue searching for additional targets", the UxVs continue searching for other targets if specified. Note 2.9: see note 2.5.			
31.		Accepts an interrupt command to RTB or move to RP despite an earlier instruction to continue searching; Note 2.10: see note 2.5.			
32.		Systems complete the mission without incident.			
33.		UAV Autonomously lands when mission complete			UAV Land Time:__________
34.		UAV Lands when out of battery power			UAV Land Time:__________
35.		If Operator selects "move to RP", the UI allows the operator to designate the location either via touch a point on the map, or inputting coordinates. Note 2.7: see note 2.5.			
36.		If Operator selected "move to RP", the UxVs move to defined RP Note 2.8: see note 2.5.			
37.		Systems complete the mission without incident.			
38.		UAV Autonomously lands when mission complete			UAV Land Time:__________
39.		UAV Lands when out of battery power			UAV Land Time:__________

APPENDIX C. MCWL LTA TABLES

Scenario: 3 Run # (circle): 1 2 3 4 5 Observer:________________ Date:________

Mission Type: Target Acquisition



Notations	Notes/Observations [Issues, Clarifications, or Other Observations]
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	

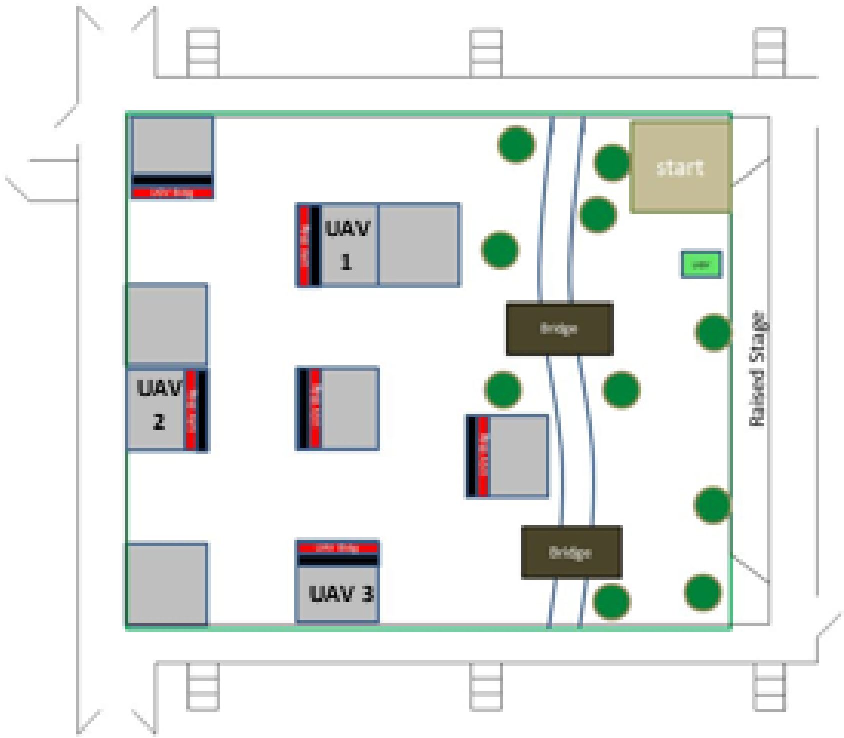
APPENDIX C. MCWL LTA TABLES

Scenario: 4 Run # (circle): 1 2 3 4 5 Observer:____________________ Date:________

Mission Type: Target Acquisition

Scenario 4 - Target Not Present

The system will conduct this mission while reusing the map built in Scenario 1.5, which will be loaded fresh between each run. The system will be trained to recognize the face of the PoI. However, no humans will be present in the AoI. The system will be tasked to search for, recognize, and report the location of the PoI.



Start Time:______________ **Stop Time:**______________ Result(Success or Failure):______________

APPENDIX C. MCWL LTA TABLES

Scenario: 4 Run # (circle): 1 2 3 4 5 Observer:__________________________ Date:_________

Mission Type: Target Acquisition

Task #	Time Issued	Command/Event	S	F	Notes/Observations [Issues, Clarifications, or Other Observations]
1.		Operator able to designate entire area as AOI in overview map.			
2.		Operator able to designate sub-area(s) as AOI(s) Note 4.1: this functionality is not yet present but is expected in a future release.			
3.		User able to add OOIs & POIs			# POI Added:____ # OOI Added:____
4.		Ability to select Find mission in UI			
5.		Ability to execute Find mission			
6.		UGV searches within AOI			
7.		UGV Stays within AOI			
8.		UGV accurately recognizes if it cannot complete mission, and alerts operator			
9.		UGV alerts Operator in UI to launch UAV to assist in mission if it identifies an area not visible to the UGV			
10.		Operator is able to accept or deny request to launch UAV			Operator selected to: Approves or Deny
11.		UGV continues searching alone if prompt for UAV is denied.			

APPENDIX C. MCWL LTA TABLES

Scenario: 4 Run # (circle): 1 2 3 4 5 Observer:________________________ Date:__________

Mission Type: Target Acquisition

Task #	Time Issued	Command/Event	S	F	Notes/Observations (Issues, Clarifications, or Other Observations)
12.		UAV Launches when request accepted			UAV Launch Time:__________
13.		UAV only searches regions not visible to UGV			UAV Buildings Mapped # (circle): 1 2 3
14.		System appears to fuse UGV & UAV maps correctly			Visual Inspection
15.		POI(s) successfully detected by UGV			# POI Dectected:____
16.		OOI(s) successfully detected by UGV			# OOI Detected:____
17.		User Prompted to confirm/deny			
18.		Ability to confirm POI/OOI detection			
19.		Ability to Deny detection			
20.		Successful response action to Accept/Deny			
		reports that it has completed a thorough search of the AoI without locating the PoI/OoI			
		UI queries Operator to RTB, move to a designated RP for retrieval, or continue searching for additional targets including revisiting areas it has already explored. Note 4.2: this functionality is not yet present but is expected in a future release.			

APPENDIX C. MCWL LTA TABLES

Scenario: 4 Run # (circle): 1 2 3 4 5 Observer:______________ Date:__________

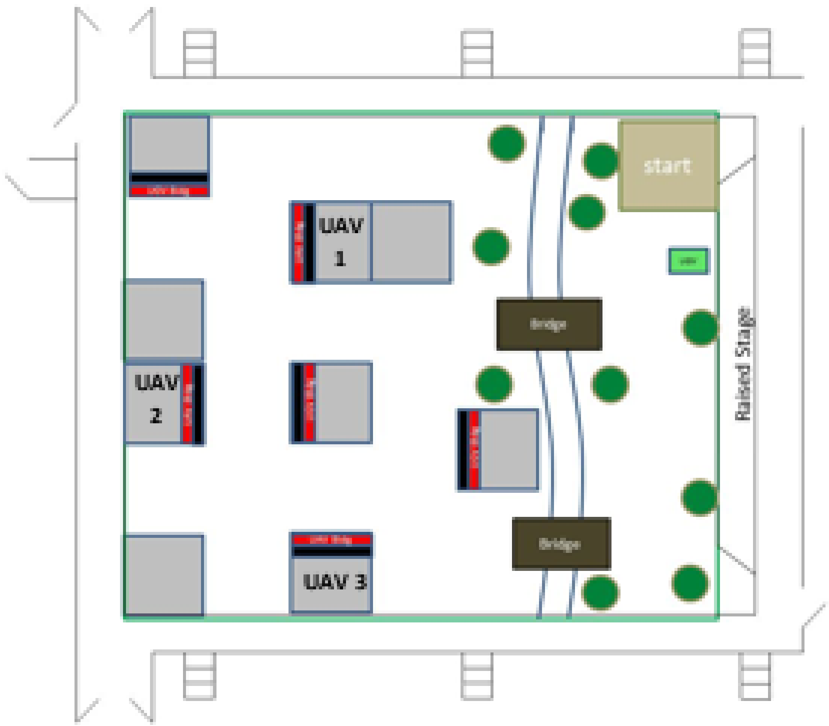
Mission Type: Target Acquisition

Task #	Time Issued	Command/Event	S	F	Notes/Observations [Issues, Clarifications, or Other Observations]
21.		If Operator selected "continue searching", the UxVs continue searching, including revisiting areas it has already explored. Note 4.3: see note4.2.			
22.		Accepts an interrupt command to RTB or move to RP despite an earlier instruction to continue searching; Note 4.4: see note 4.2.			
23.		Systems complete the mission without incident.			
24.		UAV Autonomously lands when mission complete			UAV Land Time:__________
25.		UAV Lands when out of battery power			UAV Land Time:__________
26.		If Operator selects "move to RP", the UI allows the operator to designate the location either via touch a point on the map, or inputting coordinates Note 4.5: see note 4.2.			
27.		If Operator selected "move to RP", the UxVs move to defined RP Note 4.6: see note 4.2.			
28.		Systems complete the mission without incident.			
29.		UAV Autonomously lands when mission complete			UAV Land Time:__________
30.		UAV Lands when out of battery power			UAV Land Time:__________

APPENDIX C. MCWL LTA TABLES

Scenario: 4 Run # (circle): 1 2 3 4 5 Observer:____________________________ Date:__________

Mission Type: Target Acquisition



Notations	Notes/Observations (Issues, Clarifications, or Other Observations)
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	

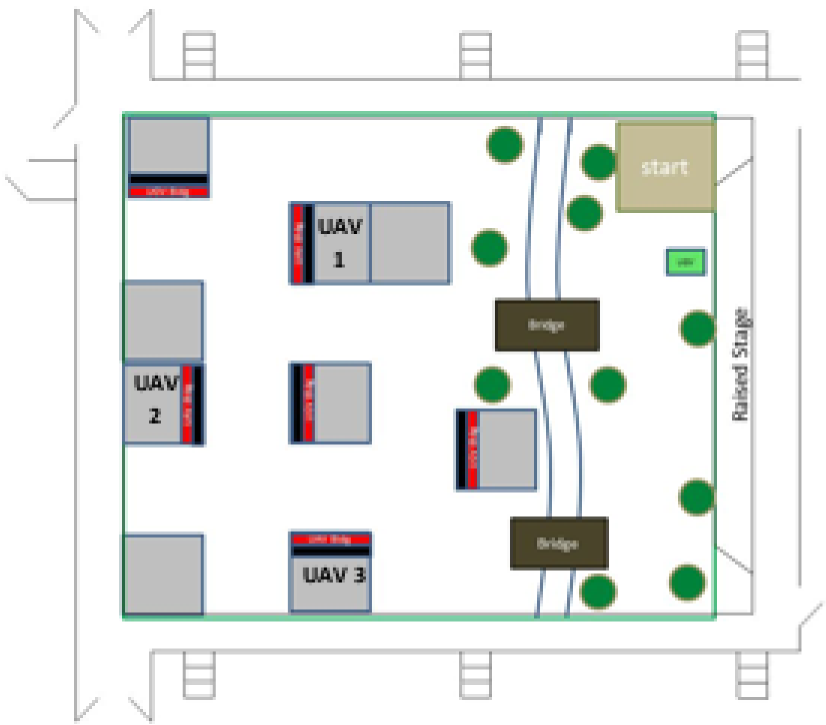
APPENDIX C. MCWL LTA TABLES

Scenario: 5 Run # (circle): 1 2 3 4 5 Observer:__________________________ Date:__________

Mission Type: Target Acquisition

Scenario 5 – Only Incorrect Target(s) Present

The system will conduct this mission while reusing the map built in Scenario 1.5 "Jointly Produce Map of Alternate Environment", which will be loaded fresh between each run. The system will be trained to recognize the face of the PoI. However, only one or two other individuals (decoys), and not the PoI, will be present in the AoI. Decoys may be located out in the open, and/or within the UGV view Bldg and/or within the UAV view bldg. The system will be tasked to search for, recognize, and report the location of the PoI.



Start Time:________________ **Stop Time:**________________ Result(Success or Failure):__________________

APPENDIX C. MCWL LTA TABLES

Scenario: 5 Run # (circle): 1 2 3 4 5 Observer:____________ Date:________

Mission Type: Target Acquisition

Task #	Time Issued	Command/Event	S	F	Notes/Observations (Issues, Clarifications, or Other Observations)
1.		Operator able to designate entire area as AOI in overview map.			
2.		Operator able to designate sub-area(s) as AOI(s) Note 5.1: this functionality is not yet present but is expected in a future release.			
3.		User able to add OOIs & POIs			# POI Added:____ # OOI Added:____
4.		Ability to select Find mission in UI			
5.		Ability to execute Find mission			
6.		UGV searches within AOI			
7.		UGV Stays within AOI			
8.		UGV accurately recognizes if it cannot complete mission, and alerts operator			
9.		UGV alerts Operator in UI to launch UAV to assist in mission if it identifies an area not visible to the UGV			
10.		Operator is able to accept or deny request to launch UAV			Operator selected to: Approves or Deny
11.		UGV continues searching alone if prompt for UAV is denied.			

APPENDIX C. MCWL LTA TABLES

Scenario: 5 Run # (circle): 1 2 3 4 5 Observer:________________ Date:________

Mission Type: Target Acquisition

Task #	Time Issued	Command/Event	S	F	Notes/Observations (Issues, Clarifications, or Other Observations)
12.		UAV Launches when request accepted			UAV Launch Time:__________
13.		UAV only searches regions not visible to UGV			UAV Buildings Mapped # (circle): 1 2 3
14.		System appears to fuse UGV & UAV maps correctly			Visual Inspection
15.		POI(s) successfully detected by UGV			# POI Dectected:____
16.		OOI(s) successfully detected by UGV			# OOI Detected:____
17.		User Prompted to confirm/deny			
18.		Ability to confirm POI/OOI detection			
19.		Ability to Deny detection			
20.		Successful response action to Accept/Deny			
		reports that it has completed a thorough search of the AoI without locating the PoI/OoI			
		UI queries Operator to RTB, move to a designated RP for retrieval, or continue searching for additional targets including revisiting areas it has already explored. Note5.2: this functionality is not yet present but is expected in a future release.			

APPENDIX C. MCWL LTA TABLES

Scenario: 5 Run # (circle): 1 2 3 4 5 Observer:________________ Date:__________

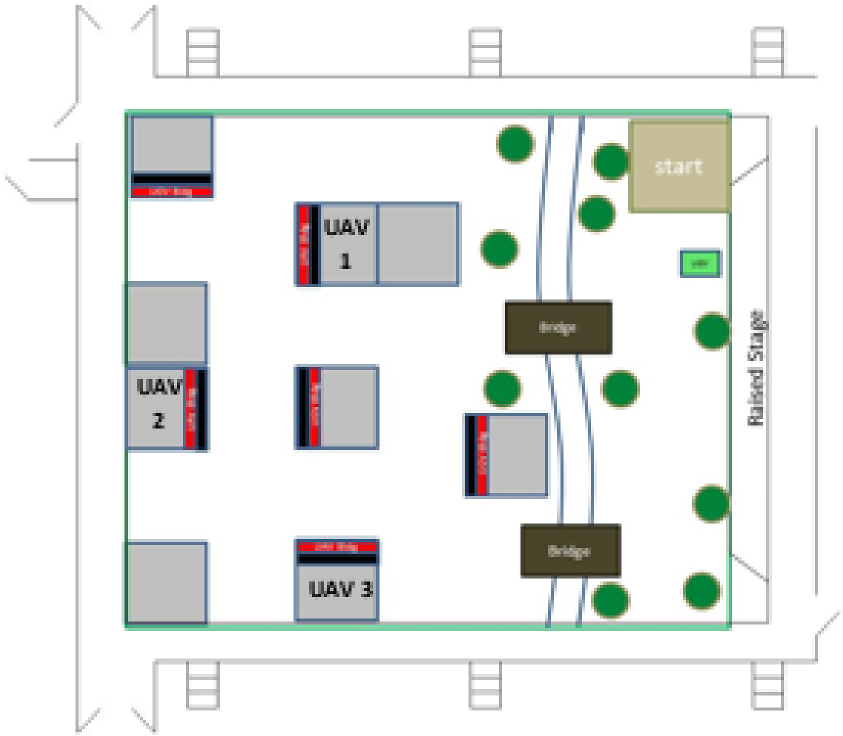
Mission Type: Target Acquisition

Task #	Time Issued	Command/Event	S	F	Notes/Observations [Issues, Clarifications, or Other Observations]
21.		If Operator selected "continue searching", the UxVs continue searching, including revisiting areas it has already explored. Note 5.3: see note 5.2.			
22.		Accepts an interrupt command to RTB or move to RP despite an earlier instruction to continue searching; Note 5.4: see note 5.2.			
23.		Systems complete the mission without incident.			
24.		UAV Autonomously lands when mission complete			UAV Land Time:__________
25.		UAV Lands when out of battery power			UAV Land Time:__________
26.		If Operator selects "move to RP", the UI allows the operator to designate the location either via touch a point on the map, or inputting coordinates Note 5.5: see note 5.2.			
27.		If Operator selected "move to RP", the UxVs move to defined RP Note 4.6: see note 4.2.			
28.		Systems complete the mission without incident.			
29.		UAV Autonomously lands when mission complete			UAV Land Time:__________
30.		UAV Lands when out of battery power			UAV Land Time:__________

APPENDIX C. MCWL LTA TABLES

Scenario: 5 Run # (circle): 1 2 3 4 5 Observer:______________ Date:__________

Mission Type: Target Acquisition



Notations	Notes/Observations (Issues, Clarifications, or Other Observations)
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	

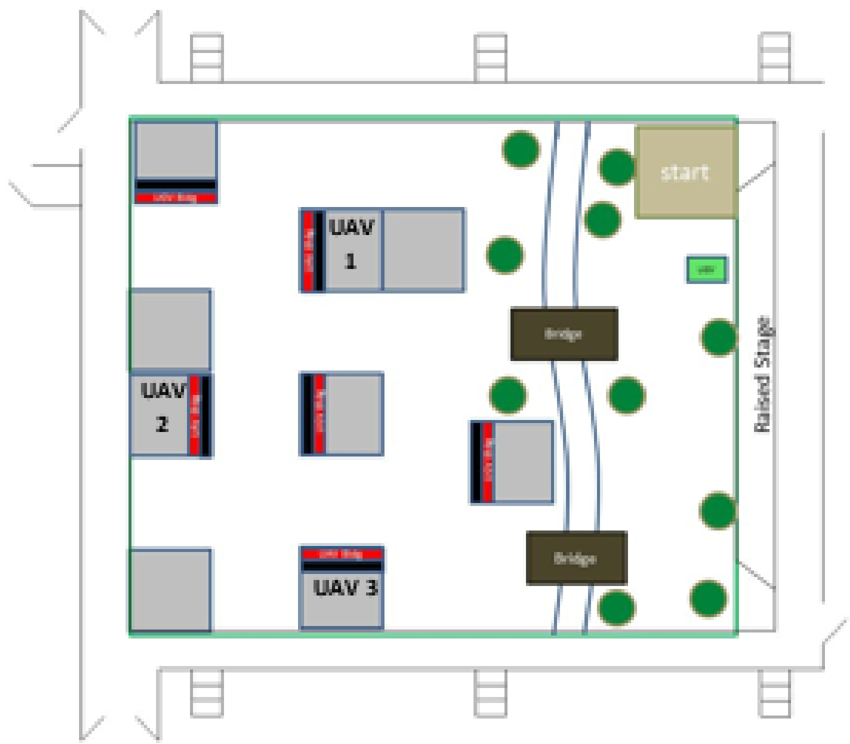
APPENDIX C. MCWL LTA TABLES

Scenario: 6   Run # (circle): 1 2 3 4 5   Observer: ______________________   Date: __________

Mission Type: Target Acquisition

Scenario 6 – Both Correct & Incorrect Targets Present

The system will conduct this mission while reusing the map built in Scenario 1.5 "Jointly Produce Map of Alternate Environment", which will be loaded fresh between each run. The system will be trained to recognize the face of the PoI. Both decoys and the PoI will be present in the AoI. Decoys and the PoI may be located out in the open (but the PoI may not have his/her face in direct line of sight with the start position), and/or within the UGV view Bldg and/or within the UAV view Bldg, but the decoys will be closer to the starting point, while the PoI will be further away from it, such that the decoys will be encountered before the PoI. The system will be tasked to search for, recognize, and report the location of the PoI.



Start Time: ______________ Stop Time: ______________ Result(Success or Failure): ______________

APPENDIX C. MCWL LTA TABLES

Scenario: 6 Run # (circle): 1 2 3 4 5 Observer:______________ Date:__________

Mission Type: Target Acquisition

Task #	Time Issued	Command/Event	S	F	Notes/Observations [Issues, Clarifications, or Other Observations]
1.		Operator able to designate entire area as AOI in overview map.			
2.		Operator able to designate sub-area(s) as AOI(s) Note 6.1: this functionality is not yet present but is expected in a future release.			
3.		User able to add OOIs & POIs			# POI Added:____ # OOI Added:____
4.		Ability to select Find mission in UI			
5.		Ability to execute Find mission			
6.		UGV searches within AOI			
7.		UGV Stays within AOI			
8.		UGV accurately recognizes if it cannot complete mission, and alerts operator			
9.		UGV alerts Operator in UI to launch UAV to assist in mission if it identifies an area not visible to the UGV			
10.		Operator is able to accept or deny request to launch UAV			Operator selected to: Approves or Deny
11.		UGV continues searching alone if prompt for UAV is denied.			

APPENDIX C. MCWL LTA TABLES

Scenario: 6 Run # (circle): 1 2 3 4 5 Observer:____________ Date:________

Mission Type: Target Acquisition

Task #	Time Issued	Command/Event	S	F	Notes/Observations (Issues, Clarifications, or Other Observations)
12.		UAV Launches when request accepted			UAV Launch Time:________
13.		UAV only searches regions not visible to UGV			UAV Buildings Mapped # (circle): 1 2 3
14.		System appears to fuse UGV & UAV maps correctly			Visual Inspection
15.		POI(s) successfully detected by UGV			# POI Dectected:____
16.		OOI(s) successfully detected by UGV			# OOI Detected:____
17.		User Prompted to confirm/deny			
18.		Ability to confirm POI/OOI detection			
19.		Ability to Deny detection			
20.		Successful response action to Accept/Deny			
21.		Target coordinates are successfully sent to LOC/Stilleto Note: Not a UTACC test.			
22.		UI displays message from LOC/Stiletto "Request Engagement?" and allows user to select "yes" or "no". Note: Not a UTACC test.			
23.		UI displays message from LOC/Stiletto "Missile Launched". Note: Not a UTACC test.			

APPENDIX C. MCWL LTA TABLES

Scenario: 6 Run # (circle): 1 2 3 4 5 Observer:__________ Date:__________

Mission Type: Target Acquisition

Task #	Time Issued	Command/Event	S	F	Notes/Observations [Issues, Clarifications, or Other Observations]
24.		UI displays query from LOC/Stiletto "Provide Battle Damage Assessment", with selectable options of "target missed", "target damaged", and "target destroyed". Note: Not a UTACC test.			
25.		Sends LOC/Stiletto appropriate Battle damage Assessment. Note: Not a UTACC test.			
26.		UI queries Operator to RTB, move to a designated RP for retrieval, or continue searching for additional targets including revisiting areas it has already explored. Note 6.2: this functionality is not yet present but is expected in a future release.			
27.		If Operator selected "continue searching", the UxVs continue searching, including revisiting areas it has already explored. Note 6.3: see note6.2.			
28.		Accepts an interrupt command to RTB or move to RP despite an earlier instruction to continue searching; Note 6.4: see note 6.2.			
29.		Systems complete the mission without incident.			
30.		UAV Autonomously lands when mission complete			UAV Land Time:__________
31.		UAV Lands when out of battery power			UAV Land Time:__________

APPENDIX C. MCWL LTA TABLES

Scenario: 6   Run # (circle): 1 2 3 4 5   Observer:____________________   Date:__________

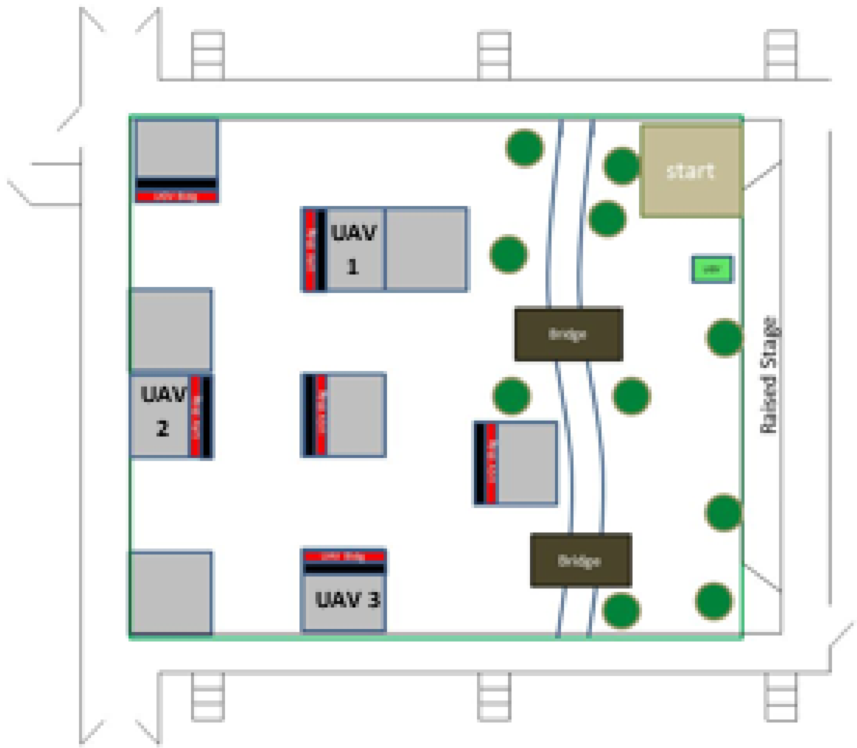
Mission Type: Target Acquisition

Task #	Time Issued	Command/Event	S	F	Notes/Observations [Issues, Clarifications, or Other Observations]
32.		If Operator selects "move to RP", the UI allows the operator to designate the location either via touch a point on the map, or inputting coordinates Note 6.5: see note 6.2.			
33.		If Operator selected "move to RP", the UxVs move to defined RP Note 6.6: see note 6.2.			
34.		Systems complete the mission without incident.			
35.		UAV Autonomously lands when mission complete			UAV Land Time:__________
36.		UAV Lands when out of battery power			UAV Land Time:__________

APPENDIX C. MCWL LTA TABLES

Scenario: 6 Run # (circle): 1 2 3 4 5 Observer:____________________ Date:________

Mission Type: Target Acquisition



Notations	Notes/Observations [Issues, Clarifications, or Other Observations]
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	

APPENDIX C. MCWL LTA TABLES

Scenario: 8 Run # (circle): 1 2 3 4 5 Observer:____________________ Date:__________

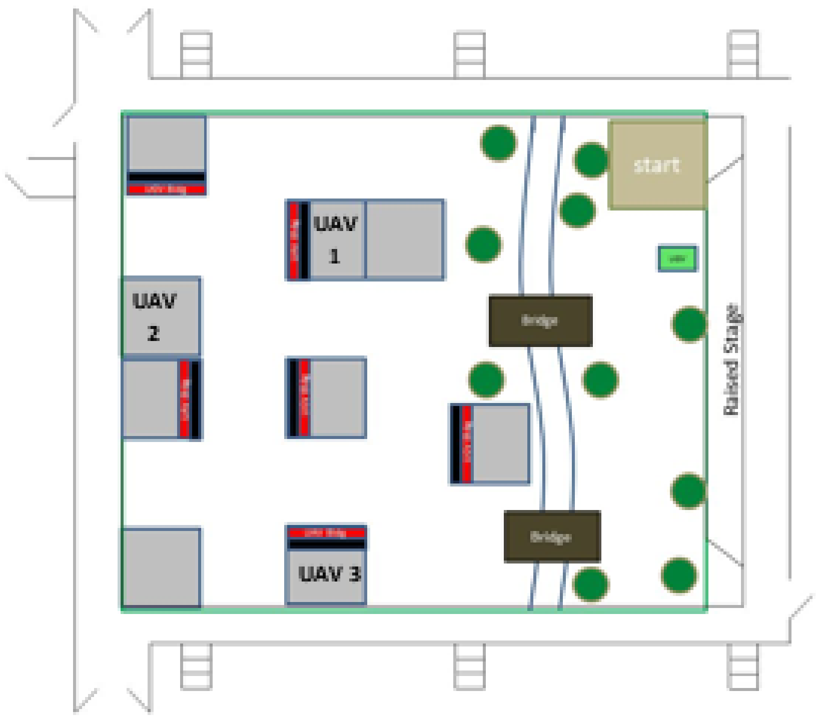
Mission Type: Target Acquisition

Scenario 8 – Start Hunt for Target at Suspected Location

The system will conduct this mission while reusing the map built in Scenario 1.5 "Jointly Produce Map of Alternate Environment", which will be loaded fresh between each run.

The system will be trained to recognize the face of the PoI. The PoI may be located out in the open (but not with his/her face in direct line of sight from the start position), and/or within the UGV view Bldg and/or within the UAV view bldg.

The system will be given the suspected location of the PoI, which will be different from his actual location. The system will be tasked to confirm his location, or find him if he's elsewhere within the AoI.



Start Time:________________ **Stop Time:**________________ Result(Success or Failure):________________

APPENDIX C. MCWL LTA TABLES

Scenario: 8 Run # (circle): 1 2 3 4 5 Observer:______________ Date:__________

Mission Type: Target Acquisition

Task #	Time Issued	Command/Event	S	F	Notes/Observations [Issues, Clarifications, or Other Observations]
1.		Operator able to designate entire area as AOI in overview map.			
2.		Operator able to designate sub-area(s) as AOI(s) Note 8.1: this functionality is not yet present but is expected in a future release.			
3.		User able to add OOIs & POIs			# POI Added:____ # OOI Added:____
4.		Ability to select Find mission in UI			
5.		Ability to execute Find mission			
6.		prompts user with the yes/no option to designate a suspected location within the AoI to head to first, and further presents the option to designate this via either touch or GPS coordinates. Note 8.2: this functionality is not yet present but is expected in a future release.			
7.		plans most direct path to the suspected location and displays this to the Operator; Note 8.3: this functionality is not yet present but is expected in a future release.			
8.		allows Operator to force a replan to the suspected location by designating no-go locations; Note 8.4: this functionality is not yet present but is expected in a future release.			

APPENDIX C. MCWL LTA TABLES

Scenario: 8 Run # (circle): 1 2 3 4 5 Observer:________________ Date:________

Mission Type: Target Acquisition

Task #	Time Issued	Command/Event	S	F	Notes/Observations (Issues, Clarifications, or Other Observations)
9.		allows Operator to plan an entirely different path to the suspected location if preferred; *Note 8.5: this functionality is not yet present but is expected in a future release.*			
10.		keeps alert for the PoI while on the way to the suspected location;			
11.		proceeds directly to the suspected location before expanding its search; *Note 8.6: this functionality is not yet present but is expected in a future release.*			
12.		notifies Operator of UTACC's arrival at suspected location; *Note 8.7: this functionality is not yet present but is expected in a future release.*			
13.		slowly expands its search radius if the PoI is not at the suspected location; *Note 8.8: this functionality is not yet present but is expected in a future release.*			
14.		UGV searches within AOI			
15.		UGV Stays within AOI			
16.		UGV accurately recognizes if it cannot complete mission, and alerts operator			
17.		UGV alerts Operator in UI to launch UAV to assist in mission if it identifies an area not visible to the UGV			

APPENDIX C. MCWL LTA TABLES

Scenario: 8 Run # (circle): 1 2 3 4 5 Observer:________________ Date:________

Mission Type: Target Acquisition

Task #	Time Issued	Command/Event	S	F	Notes/Observations (Issues, Clarifications, or Other Observations)
18.		Operator is able to accept or deny request to launch UAV			Operator selected to: Approves or Deny
19.		UGV continues searching alone if prompt for UAV is denied.			
20.		UAV Launches when request accepted			UAV Launch Time:________
21.		UAV only searches regions not visible to UGV			UAV Buildings Mapped # (circle): 1 2 3
22.		System appears to fuse UGV & UAV maps correctly			Visual Inspection
23.		POI(s) successfully detected by UGV			# POI Dectected:____
24.		OOI(s) successfully detected by UGV			# OOI Detected:____
25.		User Prompted to confirm/deny			
26.		Ability to confirm POI/OOI detection			
27.		Ability to Deny detection			
28.		Successful response action to Accept/Deny			
29.		Target coordinates are successfully sent to LOC/Stilleto Note: Not a UTACC test.			

APPENDIX C. MCWL LTA TABLES

Scenario: 8 Run # (circle): 1 2 3 4 5 Observer:__________ Date:________

Mission Type: Target Acquisition

Task #	Time Issued	Command/Event	S	F	Notes/Observations [Issues, Clarifications, or Other Observations]
30.		UI displays message from LOC/Stiletto "Missile Launched". Note: Not a UTACC test.			
31.		UI displays message from LOC/Stiletto "Request Engagement?" and allows user to select "yes" or "no". Note: Not a UTACC test.			
32.		UI displays query from LOC/Stiletto "Provide Battle Damage Assessment", with selectable options of "target missed", "target damaged", and "target destroyed". Note: Not a UTACC test.			
33.		Sends LOC/Stiletto appropriate Battle damage Assessment. Note: Not a UTACC test.			
34.		UI queries Operator to RTB, move to a designated RP for retrieval, or continue searching for additional targets including revisiting areas it has already explored. Note 8.9: this functionality is not yet present but is expected in a future release.			
35.		If Operator selected "continue searching", the UxVs continue searching, including revisiting areas it has already explored. Note 8.10: see note 8.9.			
36.		Accepts an interrupt command to RTB or move to RP despite an earlier instruction to continue searching. Note 8.11: see note 8.9.			
37.		Systems complete the mission without incident.			

APPENDIX C. MCWL LTA TABLES

Scenario: 8 Run # (circle): 1 2 3 4 5 Observer:__________________________ Date:__________

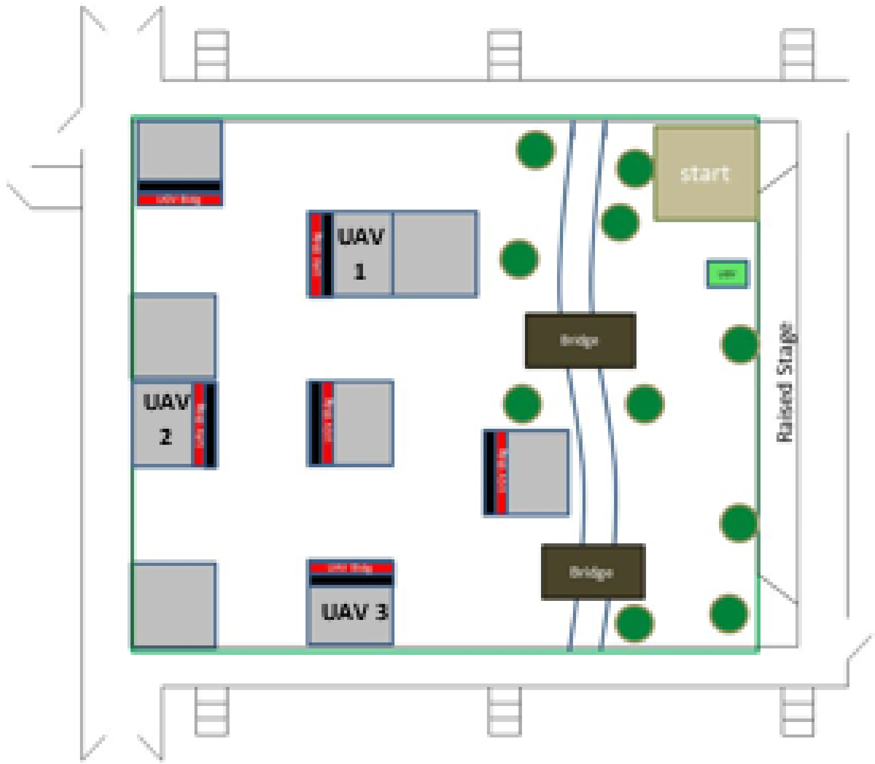
Mission Type: Target Acquisition

Task #	Time Issued	Command/Event	S	F	Notes/Observations (Issues, Clarifications, or Other Observations)
38.		UAV Autonomously lands when mission complete			UAV Land Time:______________
39.		UAV Lands when out of battery power			UAV Land Time:______________
40.		If Operator selects "move to RP", the UI allows the operator to designate the location either via touch a point on the map, or inputting coordinates Note 8.12: see note 8.9.			
41.		If Operator selected "move to RP", the UxVs move to defined RP Note 8.13: see note 8.9.			
42.		Systems complete the mission without incident.			
43.		UAV Autonomously lands when mission complete			UAV Land Time:______________
44.		UAV Lands when out of battery power			UAV Land Time:______________

APPENDIX C. MCWL LTA TABLES

Scenario: 8 Run # (circle): 1 2 3 4 5 Observer: ______________________ Date: ________

Mission Type: Target Acquisition



Notations	Notes/Observations (Issues, Clarifications, or Other Observations)
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